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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**SITE SELECTION FOR OPTICAL MONITORING EQUIPMENT (IMPROVE PROTOCOL)**
TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4050**
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AUTHORIZATIONS

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PROGRAM MANAGER	David L. Dietrich	
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OTHER		

REVISION HISTORY

REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	Add responsibilities and equipment.	October 1996	

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) outlines site selection criteria for optical monitoring instruments operated according to IMPROVE Protocol. Documented site selection criteria and procedures assure consistent, quality data at sites that exhibit most or all of the following characteristics:

- Be located in an area representative of the air mass to be monitored
- Be removed from local pollution sources (e.g., vehicle exhaust, wood smoke, road dust, etc.)
- Have AC power, solar exposure, and/or telephone lines available
- Have telephone lines and AC power or solar exposure available
- Allow for proper orientation of nephelometer sample inlet
- Be close to an existing aerosol monitoring station or other instruments that are being used to monitor the air mass of interest
- Be representative of the same air mass measured by associated aerosol (particle monitors) and scene (camera) instrumentation
- Have a clear, unobstructed sight path between the transmissometer components
- Be representative of regional (not local) visibility
- Be secure from vandalism
- Have available servicing personnel (operator)
- Be reasonably accessible during all months of the year

The two (2) types of optical monitoring instruments currently operating in the IMPROVE monitoring network are Optec NGN-2 ambient nephelometers and Optec LPV-2 transmissometers. Additional, detailed instrument-specific site characteristic criteria are described in the following technical instructions (TIs):

- TI 4050-3000 *Site Selection for Optec NGN-2 Nephelometer Systems*
- TI 4050-3010 *Site Selection for Optec LPV-2 Transmissometer Systems*

This SOP serves as a guideline to facilitate the following:

- Locating potential sites
- Evaluating potential sites
- Selecting the most appropriate site from the potential sites
- Finalizing the selected site

2.0 RESPONSIBILITIES

2.1 PROGRAM MANAGER

The program manager shall:

- Inform the project manager of the location area and site-specific monitoring objectives for a proposed optical monitoring site.
- As required, review the selected site with the project manager and project-specific Contracting Officer's Technical Representative (COTR).

2.2 PROJECT MANAGER

The project manager shall:

- Prepare the project-specific siting and operational objectives, guidelines, and considerations.
- Review with the field specialist photographic documentation, maps, and other information to determine the suitability of a site.
- Select the site based on the criteria outlined in the appropriate instrument-specific technical instructions (TIs).
- As required, review the selected site with the program manager.

2.3 FIELD SPECIALIST

The field specialist shall:

- Initiate the search for potential sites by sending the pertinent siting criteria and associated materials to the local contact.
- Conduct a siting visit if required (always required for transmissometer sites).
- Contact local power and telephone companies for information concerning availability and installation.
- Obtain permission to perform any site preparation that may be required.
- Obtain permission from private or public landowners for permanent access to the monitoring location.
- Obtain permits or Environmental Impact Statements if required.
- Work with the local contact or sponsoring agency to identify a site operator and local primary contact to service the equipment.
- Review with the project manager photographic documentation, maps, and other information to determine the suitability of a site.
- Enter all site selection information in the site-specific Quality Assurance Database.

2.4 LOCAL (ON-SITE) CONTACT

The local contact shall:

- Locate and document potential sites upon receiving the siting criteria and associated materials from ARS.
- Provide the field specialist with any pertinent site-related information.
- Assist the field specialist in obtaining any site access and/or installation-related clearances or permissions.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The following equipment and materials are generally required to complete the site selection process:

- Topographic maps of the area of interest
- Camera(s) and film to photograph the proposed site and area
- A list of monitoring objectives, requirements, and associated IMPROVE protocol monitoring equipment
- A list of local sources affecting the air in the area of interest
- Information about the availability of AC power and telephone service
- Photographic Log
- Nephelometer siting:
  - An Optec NGN-2 Nephelometer Siting Information Form
  - Installation Site Photographs and Drawing Instructions
- Transmissometer sitings:
  - Brunton compass
  - Transmitter telescope unit with tripod
  - Tape measure
  - Signal mirrors
  - Binoculars
  - Shelter option diagrams
  - Solar panel array installation configuration diagrams

4.0 METHODS

This section describes site selection procedures and includes two (2) major subsections:

4.1 Nephelometer Site Selection Methods
4.2 Transmissometer Site Selection Methods

4.1 NEPHELOMETER SITE SELECTION METHODS

4.1.1 Locating Potential Sites

- Obtain siting and monitoring objective criteria from the project manager.
- Locate potential sites using maps and through consultation with the local contact(s).
- Send siting package to the local contact.
- Perform a field survey, document site selection with photographs and maps, and collect information about site accessibility, security, and special requirements.
- Check returned siting package for completeness.

4.1.2 Reviewing and Selecting Potential Sites

- Evaluate potential sites after review of the siting information.
- Select the best site.

4.1.3 Finalizing Site Selection

After evaluating potential sites and selecting the most appropriate site, the following actions are required to finalize the site selection:

- Obtain approval of the selected site from the project manager.
- Obtain approval from the program manager.
- If required, obtain approval from the project-specific COTR.
- Provide a detailed description of the proposed installation to the local contact and property manager.
- Obtain permission for site use and any site preparation.
- Complete permits or Environmental Impact Statements if required.
- Initiate installation protocols as described in TI 4070-3000, *Installation of Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)* and TI 4070-3001, *Site Documentation for Optec NGN-2 Nephelometer Systems*.

4.2 TRANSMISSOMETER SITE SELECTION METHODS

4.2.1 <u>Siting Criteria</u>

Criteria categories that must be considered when siting a transmissometer system are:

- Sight path (height above ground, length, and vertical angle)
- Air mass (the air mass along the sight path must be representative of the regional air mass)
- Location characteristics (of the individual transmissometer transmitter and receiver stations)
- Selection of appropriate shelters and solar panel arrays (solar-powered sites)

4.2.2 <u>Locating Potential Sites</u>

- Obtain siting and monitoring objective criteria from the project manager.
- Locate potential sites using maps and through consultation with the local contact(s).
- Send siting package to the local contact.
- Perform a field survey, document site selection with photographs and maps, and collect information about site accessibility, security, and special requirements.
- Check returned siting package for completeness.
- Make a preliminary evaluation of the proposed sites.
- Schedule a siting trip and coordinate with the site operator.
- Determine the need for any clearances and document related information.
- Gather additional information and evaluate potential sites.

4.2.3 <u>Reviewing and Selecting Potential Sites</u>

- Evaluate proposed sites after review of the siting information and site visit.
- Select the best site.

4.2.4 <u>Finalizing Site Selection</u>

After evaluating potential sites and selecting the most appropriate site, the following actions are required to finalize the site selection:

- Obtain approval of the selected site from the project manager.
- Obtain approval from the program manager.

- If required, obtain approval from the project-specific COTR.

- Provide a detailed description of the proposed installation to the local contact and property manager.

- Obtain permission for site use and any site preparation.

- Complete permits or Environmental Impact Statements if required.

- Initiate installation protocols as described in TI 4070-3010, *Installation and Site Documentation of Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**SITE SELECTION FOR OPTEC NGN-2 NEPHELOMETER SYSTEMS**
TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4050-3000**
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AUTHORIZATIONS

TITLE	NAME	SIGNATURE
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OTHER		

REVISION HISTORY

REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	Additions to responsibilities and methods.	October 1996	

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LIST OF FIGURES

1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes site selection requirements for Optec NGN-2 nephelometer systems operated according to IMPROVE Protocol. The purpose of documented site selection requirements is to assure consistent quality data capture and minimize data loss by selecting a site that exhibits most or all of the following characteristics:

- Be located in an area representative of the air mass to be monitored
- Be removed from local pollution sources and away from obstructions that could affect the air flow in the area of the instrument
- Have AC power and telephone lines available
- Allow for orientation of the nephelometer sample inlet towards true north
- Be representative of the same air mass measured by associated aerosol (particle monitors) and scene (camera) instrumentation
- Meet the same criteria used to site particle samplers, including:
    - Have a distance from the instrument to the nearest obstruction greater than 2.5 times the difference in heights of the instrument and the obstruction
    - Be representative of regional (not local) visibility
    - Be removed from local pollution influences (e.g., vehicle exhaust, wood smoke, road dust, etc.)
- Be secure from vandalism
- Have available servicing personnel (operator)
- Be reasonably accessible during all months of the year

This TI serves as a guideline to facilitate the following:

- Locating potential sites
- Evaluating potential sites
- Selecting the most appropriate site from the potential sites
- Finalizing the selected site

Due to variation in the site configuration of IMPROVE Protocol sites, portions of this TI may not apply to every station.

2.0 RESPONSIBILITIES

2.1 PROGRAM MANAGER

The program manager shall:

- Inform the project manager of the location area and site-specific monitoring objectives for a proposed nephelometer site.
- As required, review the selected site with the project manager and the project-specific Contracting Officer's Technical Representative (COTR).

2.2 PROJECT MANAGER

The project manager shall:

- Prepare project-specific siting and operational objectives, guidelines, and considerations.
- Review with the field specialist photographic documentation, maps, and other information to determine the suitability of a site.
- Select the site for the nephelometer station based on the criteria described in this TI.
- Review the selected site with the program manager.

2.3 FIELD SPECIALIST

The field specialist shall:

- Initiate the search for potential sites by sending the pertinent siting criteria and associated materials to the local contact.
- Contact the local power and telephone companies for information concerning availability and installation of AC power and telephone service.
- Obtain permission to perform any site preparation that may be required.
- Obtain permission from private or public landowners for permanent access to the nephelometer station.
- Obtain permits or Environmental Impact Statements if required by the property manager.
- Contact the existing site operator or arrange for a new site operator to service the station.
- Review with the project manager, photographic documentation, maps, and other information to determine the suitability of a site.
- Enter all site selection information in the site-specific Quality Assurance Database.

2.4 LOCAL (ON-SITE) CONTACT

The local contact shall:

- Locate and document potential sites upon receiving the siting criteria and associated materials from the field specialist.
- Provide the field specialist with any pertinent site-related information.
- Assist the field specialist in obtaining any site access and/or installation-related clearances or permissions.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The following equipment and materials are generally required to complete the site selection process:

- Topographic maps of the area of interest
- Camera(s) and film to photograph the proposed site and area
- A list of monitoring objectives, requirements, and associated IMPROVE protocol monitoring equipment
- A list of local sources affecting the air in the area of interest
- Information about the availability of AC power and telephone service
- An Optec NGN-2 Nephelometer Siting Information Form
- Installation Site Photographs and Drawing Instructions
- A Photographic Log

4.0 METHODS

This section describes the site selection procedures and includes three (3) major subsections:

4.1 Locating Potential Sites
4.2 Reviewing and Selecting Potential Sites
4.3 Finalizing Site Selection

4.1 LOCATING POTENTIAL SITES

Site selection begins with the process of locating potential sites in the monitoring area of interest. The following steps detail the approach:

OBTAIN SITING CRITERIA	The field specialist obtains specific siting criteria from the project manager. Siting criteria may include regional or site-specific program objectives, meteorological conditions of the monitoring area and/or other considerations.

LOCATE POTENTIAL SITES

Locate potential sites from maps and through consultation with local contacts familiar with the monitoring area of interest.

SEND SITING PACKAGE TO LOCAL CONTACT

Send the nephelometer siting package to a local contact familiar with the proposed monitoring area. The siting package includes the following:

- A cover letter that includes a brief description of the monitoring area and associated program objectives.
- An Optec NGN-2 Nephelometer Siting Information Form (Figure 4-1).
- A disposable 35 mm camera or a camera and roll of 35 mm print film.
- Installation Site Photographs and Drawing Instructions (Figure 4-2).
- A Photographic Log (Figure 4-3).

FIELD SURVEY AND SITE SELECTION DOCUMENTATION

The local contact should review the technical and monitoring requirements and identify potential sites and in relation to the protocols provided. Actual field surveys can be performed by the local contact, an ARS field specialist, or both.

The results of the field survey should include a series of photographs of the area. Photographs of each site location should also be provided. The location, azimuth, and predominant scenic features should be documented on the provided Photographic Log.

Identify and record the selected site location(s) on a topographic map of the area.

Record any pertinent information regarding accessibility, security, special requirements, etc.

Return the processed or unprocessed print film, Photographic Log, site location maps, and any other selection materials to ARS for final review.

CHECK RETURNED SITING PACKAGE

Check the returned nephelometer siting forms for completeness. Obtain any missing information from the local contact. Process any undeveloped film. Evaluate the photographs of each potential site. If additional photographs are required, send another camera or additional film to the local contact with instructions detailing the photographs required.

OPTEC NGN-2 NEPHELOMETER
SITING INFORMATION FORM

Site Name:

Associated Land Management Unit (Park, Forest, etc.): ______________

Your Name: ________________________

Mailing Address: ____

____

UPS Shipping Address (cannot be P.O. Box): ____

____

Telephone: ________________________

Fax: ________________________

Contacts

Primary Contact: ______________________________ Telephone: ______________________

Secondary Contact: ______________________________ Telephone: ______________________

Area Supervisor/Title: ____________________________ Telephone: ______________________

Comments: ____

____

____

IMPROVE Aerosol Sampler Location (if existing): ______________________________________

Access to the Site (road type, gates/locks, vehicle requirements): ________________________________

____

Elevation: ____

Topographic Map Name (7.5" or other appropriate scale): ______________________________________

(If possible, make a photocopy of the portion of the map that includes the site and return it with this form.)

Is a Telephone Available Nearby? (distance?): ______________________________________

Nearest Telephone Pole #, Box #, or Telephone #: ______________________________________

Is AC Power Readily Available? (distance?): ______________________________________

Quality of AC Power/Outages: ____

Describe Ground or Tower Mounting Surface: ______________________________________

Average/Max. Snow Depth at Proposed Site: ______________________________________

Do Local Sources of Haze/Smoke Exist? (e.g., a cabin that burns wood): ________________________

____

Distance from Local Sources: ____

Potential for Vandalism: ____

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Figure 4-1. Optec NGN-2 Nephelometer Siting Information Form.

OPTEC NGN-2 NEPHELOMETER
SITING INFORMATION FORM

Power Company: Name: ____________________
Contact: ____________________
Address: ____________________
____
____
____
____
Telephone: ____________________

Telephone Company: Name: ____________________
Contact: ____________________
Address: ____________________
____
____
____
____
Telephone: ____________________

Other information (Is there any additional information that will help with the installation?):

____
____
____
____

Mail Form to:

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525
Telephone: 970/484-7941
Fax: 970/484-3423

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siteinfo.frm (10/96)

Figure 4-1. (Continued). Optec NGN-2 Nephelometer Siting Information Form.

INSTALLATION SITE PHOTOGRAPHS AND DRAWING INSTRUCTIONS

1. Complete the attached log sheet to document all siting and installation photographs taken. Film should be sent to ARS in the pre-addressed, padded envelope provided. ARS will develop the exposed film.

   Suggested photographs (24-exposure roll) include:

   a. General Area - photographs of the proposed area from various angles and distances.

   b. Proposed location for the nephelometer support tower.

   c. AC line power receptacle in relation to proposed nephelometer installation.

   d. Telephone access in relation to proposed nephelometer installation.

   e. Air quality or meteorological monitoring equipment (located nearby).

   f. Any additional photographs you feel would be beneficial in preparing for the system installation.

   g. Be sure to document each photograph on the Photographic Log (see Figure 4-3).

2. Make a sketch of the proposed installation site (note true north). List approximate dimensions for buildings, fenced compounds, etc. Note the distance to and height of the nearest obstructions. If possible, include a copy of a topographic map with the site indicated. Note any additional information you believe relevant or important on the sketch or on the back of the sketch.

Figure 4-2. Installation Site Photographs and Drawing Instructions.

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Site ______________________________

Roll # ______________________________

PHOTOGRAPHIC LOG

EXPOSURE NUMBER	DATE	TIME	DESCRIPTION/COMMENTS

Figure 4-3. Example Photographic Log.

4.2 REVIEWING AND SELECTING POTENTIAL SITES

The siting package for potential sites must be reviewed to determine if any of the potential sites are acceptable. The following criteria should be used to evaluate the suitability of a potential site:

EVALUATE SITE SUITABILITY

- Overall monitoring criteria defined by the program manager
- Availability, reliability, and cost of AC power and telephone service
- Year-round site operator accessibility
- Availability of a reliable site operator
- Environmental considerations (e.g., snow depth, temperature extremes, precipitation type and amount, relative humidity, etc.) that could require deviations from the standard station configuration
- Security from potential vandalism
- Locations of obstructions or interferences
- Influence of local pollution sources
- Type and location of any collocated instrumentation
- Local land manager or land owner cooperation
- Ease of installation, including distance to nearest town

SELECT BEST SITE

Select the best site based on the results of the evaluation. Compromises may be required. Provide the selected site description, map, and photographs to the project manager for final review and approval.

4.3 FINALIZING SITE SELECTION

After evaluating potential sites and selecting the most appropriate site, the following actions are required to finalize the site selection:

- Obtain approval of the selected site from the project manager.
- As required, the final site selection and related information are presented to the program manager and/or the project-specific COTR for final review and approval.
- Provide a detailed description of the selected site, nephelometer station configuration, and method of installation to the property manager.

- Obtain permission to use the site and to arrange for any site preparation from the property manager, land manager (public lands), or land owner (private lands).

- Complete permits or Environmental Impact Statements (EISs) if required by the property manager.

- Initiate installation protocols as described in TI 4070-3000, *Installation of Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)* and TI 4070-3001, *Site Documentation for Optec NGN-2 Nephelometer Systems*.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**INSTALLATION AND SITE DOCUMENTATION FOR OPTICAL MONITORING EQUIPMENT**
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NUMBER	**4070**
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AUTHORIZATIONS		
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PROGRAM MANAGER	David L. Dietrich	
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OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) outlines the general procedures regarding installation and site documentation of optical monitoring instrumentation operated according to IMPROVE Protocol. Optical monitoring sites include those equipped with an Optec LPV transmissometer and/or Optec NGN nephelometer.

To assure quality data capture and minimize data loss, site installation and documentation procedures include:

- Installing the instrumentation, shelters, and support components in a standard configuration to ease data collection, troubleshooting, and servicing.
- Performing thorough on-site specification measurements.
- Documenting site specification measurements and other site-related information.

The following technical instructions provide detailed information regarding installing optical monitoring equipment or documenting optical site information:

- TI 4070-3000 *Installation of Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*
- TI 4070-3001 *Site Documentation for Optec NGN-2 Nephelometer Systems*
- TI 4070-3010 *Installation and Site Documentation for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*

2.0 RESPONSIBILITIES

2.1 PROGRAM MANAGER

The program manager shall review site preparation, installation requirements, and the installation schedule with the project manager.

2.2 PROJECT MANAGER

The project manager shall:

- Review site preparation, installation requirements, and the installation schedule with the program manager and/or the project-specific Contracting Officer's Technical Representative (COTR) as required.
- Schedule the system installation.
- Review final site configuration plans presented by the field specialist.
- Review the completed site documentation forms for completeness and accuracy.

2.3 FIELD SPECIALIST

The field specialist shall:

- Review the installation with the project manager.
- Coordinate with on-site personnel regarding the installation location, schedule, installation assistance, and availability of materials.
- Ship all required equipment to the site.
- Install the optical systems.
- Perform an installation calibration or field audit.
- Schedule and conduct an operator training session.
- Complete all site documentation.
- Provide completed site documentation to the data analyst.

2.4 DATA ANALYST

The data analyst shall:

- Verify transmission of data from the system upon completion of the installation.
- Enter all site documentation into the Quality Assurance Database.
- File all hard copy site documentation provided by the field specialist.

2.5 LOCAL (ON-SITE) CONTACT

The local contact shall:

- Review site preparation and installation requirements with the field specialist.
- Identify and contact local landowners, land managers, primary contacts, and site operators regarding site installation and routine maintenance requirements.
- Perform or ensure completion of any site preparation required prior to the installation.
- Assist in obtaining any site-, installation-, and regular servicing-related clearances and permits.
- Provide on-site equipment and tools required during the installation.
- As required, provide assistance with the installation.
- Schedule the operator training session with pertinent routine servicing personnel and the field specialist.

3.0 REQUIRED EQUIPMENT AND MATERIALS

3.1 EQUIPMENT AND MATERIALS REQUIRED FOR NEPHELOMETER INSTALLATIONS

- Optec NGN-2 ambient nephelometer with extra lamps
- Rohn tower, base plate, and hardware
- Solar radiation and precipitation shield
- Precipitation hood
- Nephelometer datalogging and support subsystem
- Span gas calibration system
- Ambient air temperature and relative humidity sensor in force-aspirated shield
- AC power line and telephone line
- Complete set of installation tools
- A camera loaded with color print film
- Laptop computer equipped with PROCOMM
- Replacement connector kit
- Telephone line simulator
- Topographic maps of the area
- Information documented during the site selection process
- NGN-2 Nephelometer Site Documentation Form
- Site Operator's Manual for Nephelometer Systems
- Complete set of standard operating procedures and technical instructions regarding annual site visit procedures, calibration of monitoring systems, replacing and shipping optical components, monitoring system diagrams, site documentation, and operator maintenance procedures
- Pen or pencil

3.2 EQUIPMENT AND MATERIALS REQUIRED FOR TRANSMISSOMETER INSTALLATIONS

- Installation transmissometer with calibrated lamps

- Audit transmissometer with calibrated lamps
- Programmed data collection platform (DCP) with antenna, antenna cable, and solar panel charging system or AC-trickle charger
- AT/RH sensor with housing and cable
- Strip chart recorder and supplies
- Electronic distance meter (EDM) with mirror assembly and tripods
- Receiver and transmitter shelters with anchor assemblies
- Receiver and transmitter mounting posts and alti-azimuth bases
- Window/hood assemblies
- Terminal strip board
- Power supplies and/or solar panel assemblies
- Metal shelves for larger shelters
- Shelter anchor assemblies
- Deep-cycle batteries for solar-powered installations
- Hardware for shelter assembly, post installation, and miscellaneous installation-related tasks
- Miscellaneous servicing supplies, as detailed in TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*, TI 4110-3100, *Routine Site Operator Maintenance Procedures for LPV-2 Transmissometer Systems (IMPROVE Protocol)*, and TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*
- Concrete mix
- Caulking
- Rock/concrete epoxy capsules
- Surge protectors
- Solar panel regulators
- Dust pan, brushes, and broom
- AC or battery jigsaw with wood and metal blades

- AC or battery hammer drill with 5/8" hammer bit
- Hand sledge hammer and 5/8" star drill
- Wheelbarrow
- Wood saw
- Topographic maps of the area
- Ruler and protractor
- Photographs of sites, sight path, shelters, equipment configurations, etc.
- Information documented during the site selection process
- Transmissometer Site Description Sheet
- Site Map and Site Specifications Sheet
- Site Operator's Manual for Transmissometer Monitoring Systems
- Complete set of standard operating procedures and technical instructions regarding annual site visit procedures, calibration of monitoring systems, replacing and shipping optical components, monitoring system diagrams, site documentation, and operator maintenance procedures
- Pen or pencil

4.0 METHODS

This section includes four (4) major subsections that describe installation and documentation procedures applied to optical instruments:

4.1 Site Preparation and Communication
4.2 Installation Methods and Procedures
4.3 Operator Training
4.4 Site Documentation and Documentation Archival

4.1 SITE PREPARATION AND COMMUNICATION

Site preparation includes reviewing installation requirements with the local contact and scheduling all site preparation activities, including obtaining permission from landowners to access the monitoring location, determining site operators, and ensuring that all other necessary installation assistance is obtained.

The project manager schedules a site installation visit. The field technician schedules assistance from on-site personnel (such as obtaining required tools and equipment) and an operator training session.

4.2 INSTALLATION METHODS AND PROCEDURES

Nephelometer systems require installation of a tower, the nephelometer (with solar radiation and precipitation shield, precipitation hood, and AT/RH sensor) and support system components (datalogging and control subsystem, and span gas calibration system). Specific installation requirements are detailed in TI 4100-3375, *Replacing and Shipping Nephelometer System Components*. In addition, AC line power and a telephone line must be connected. After installation of the instrumentation, the entire system operation must be calibrated and verified.

Transmissometer systems require installation of shelters for both the transmitter and receiver units, mounting posts, the specific transmissometer components (transmitter and receiver) and support system components (alti-azimuth bases, terminal strip, AT/RH sensor, DCP and antenna, and strip chart recorder). Specific installation requirements are detailed in TI 4110-3375, *Replacing and Shipping Transmissometer Components*. In addition, either AC line power or DC solar power installation is required. After installation of the instrumentation, the entire system operation must be verified, and sight path distance measured.

4.3 OPERATOR TRAINING

Upon completion of the optical installation and system operation verification, all operators, back-up operators, and any other involved or interested on-site personnel are trained according to the procedures in TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)* or TI 4115-3005, *Annual Site Visit Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*. Operators are trained in an overview of the monitoring program, instrument function and theoretical operation, component overview, routine servicing, and troubleshooting procedures. The site operator's manual for the appropriate instrumentation is reviewed and a copy is left with the site operators.

4.4 SITE DOCUMENTATION AND DOCUMENTATION ARCHIVAL

The field specialist completes site documentation including a site visit trip report, site specifications, geographic reference including landmarks, and location of monitoring equipment. Photographic documentation is also collected of the instrumentation.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**INSTALLATION OF OPTEC NGN-2 NEPHELOMETER SYSTEMS (IMPROVE PROTOCOL)**
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REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	Added respon's and site preparation steps.	July 1996	

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the procedures for installing Optec NGN-2 nephelometer stations operated according to IMPROVE Protocol. The purpose of this TI is also to assure quality data capture and minimize data loss by installing the instrumentation and support components in a standard configuration to ease data collection, troubleshooting, and servicing.

Figure 1-1 is an annotated photograph of a standard nephelometer station. The major station components are:

- Four meter Rohn tower (14 feet total - two 7 foot sections)
- Tower base plate
- Tower hardware (guy wires, clamps, etc.)
- Solar radiation and precipitation shield
- Precipitation hood
- Optec NGN-2 ambient nephelometer
- Nephelometer datalogging and support subsystem
- Span gas calibration system
- Rotronics MPF-100 ambient air temperature and relative humidity sensor in force-aspirated shield
- AC power line
- Telephone line (at sites without cellular telephone access)

Although nephelometer station configurations typically consist of the same major components, individual installations may vary considerably from the standard tower mount configuration described in this TI.

This TI is referenced from Standard Operating Procedure (SOP) 4070, *Installation and Site Documentation for Optical Monitoring Equipment*. The following SOPs and TIs are referenced in this document:

- TI 4070-3001 *Site Documentation for Optec NGN-2 Nephelometer Systems*
- TI 4100-3100 *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*
- TI 4100-3350 *NGN-2 Nephelometer Monitoring System Diagrams and Component Descriptions*

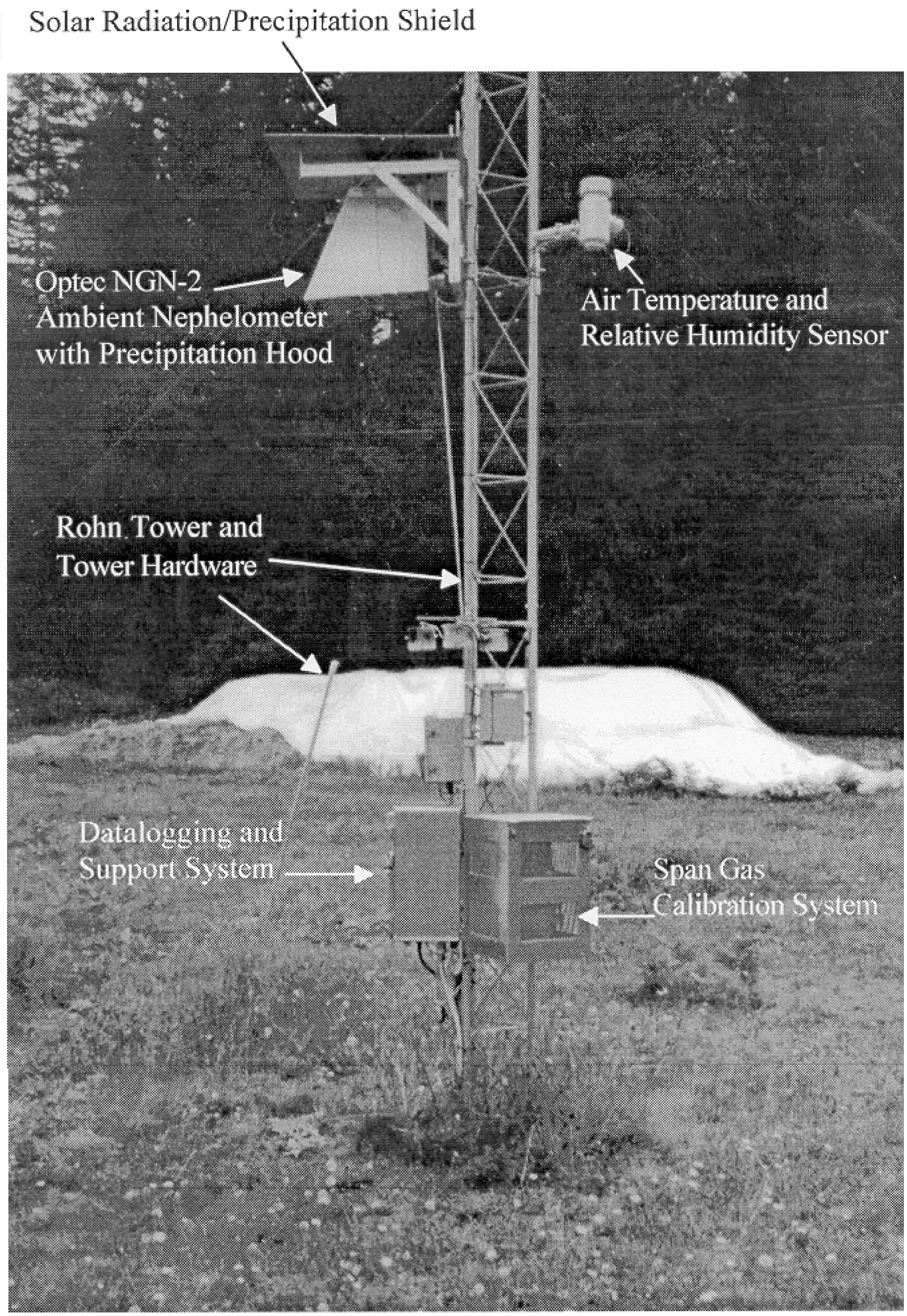

Figure 1-1. Typical Optec NGN-2 Nephelometer Station.

- TI 4100-3375 *Replacing and Shipping Nephelometer System Components*
- TI 4115-3005 *Annual Site Visit Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*
- SOP 4200 *Calibration of Optical Monitoring Systems (IMPROVE Protocol)*
- TI 4200-2000 *Calibration of Optec NGN-2 Nephelometers (IMPROVE Protocol)*

2.0 RESPONSIBILITIES

2.1 PROGRAM MANAGER

The program manager shall review site preparation, installation requirements, and the installation schedule with the project manager.

2.2 PROJECT MANAGER

The project manager shall:

- Review site preparation, installation requirements, and the installation schedule with the program manager and/or the project-specific Contracting Officer's Technical Representative (COTR) as required.
- Review final site preparation and installation plans with the field specialist.
- Schedule the installation.

2.3 FIELD SPECIALIST

The field specialist shall:

- Review final site preparation and installation plans with the project manager.
- Inform the local contact of the installation schedule.
- Review site preparation and installation requirements with the local contact, as required.
- Maintain communications with the local contact during site preparation. Verify that all required site preparation is completed prior to installation.
- Verify that all required clearances and permissions relating to the specific site, system installation, and regular servicing have been obtained prior to the installation.
- Schedule and arrange for any on-site assistance needed during the installation.
- Ship all required equipment to the site.
- Install the nephelometer station according to this TI.

- Train the site operator(s) according to TI 4115-3005, *Annual Site Visit Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*.

- Calibrate the nephelometer system according to TI 4200-2000, *Calibration of Optec NGN-2 Nephelometers (IMPROVE Protocol)*.

- Complete all required site documentation according to TI 4070-3001, *Site Documentation for Optec NGN-2 Nephelometer Systems*.

- Provide completed site documentation to the data analyst.

2.4 DATA ANALYST

The data analyst shall:

- Verify transmission of data from the system upon completion of the installation.

- Enter all site documentation into the Quality Assurance Database.

- File all hardcopy site documentation provided by the field specialist.

2.5 LOCAL (ON-SITE) CONTACT

The local contact shall:

- Review site preparation and installation requirements with the field specialist.

- Identify and contact local landowners, land managers, primary contacts, and site operators regarding site installation and routine maintenance requirements.

- Perform or ensure completion of any site preparation required prior to the installation.

- Assist in obtaining any site-, installation-, and regular servicing-related clearances and permits.

- Provide on-site equipment and tools required during the installation.

- As required, provide assistance with the installation.

- Schedule the operator training session with pertinent routine servicing personnel and the field specialist.

3.0 REQUIRED EQUIPMENT AND MATERIALS

All system components listed in Section 1.0 of this TI are shipped to the site prior to installation. The following additional equipment and materials are also required:

- Complete set of installation tools

- Replacement connector kit

- Computer equipped with nephelometer/logger box communication capabilities
- Telephone line simulator
- Extra nephelometer lamps
- PVC pipe or flexible conduit
- All technical instructions (TIs) and standard operating procedures (SOPs) listed in Section 1.0
- Site Operator's Manual for Nephelometer Systems
- Nephelometer Installation Checklist
- Camera and color print film
- Pen or pencil

4.0 METHODS

Installation of Optec NGN-2 nephelometer stations is detailed in the following sixteen (16) subsections:

4.1 Site Preparation and Communication
4.2 Installing the Tower
4.3 Installing the Solar Radiation and Precipitation Shield
4.4 Installing the Precipitation Hood
4.5 Installing the Nephelometer
4.6 Installing the Datalogging and Control Subsystem
4.7 Installing the Rotronics AT/RH Sensor and Force-Aspirated Shield
4.8 Installing the Span Gas Calibration System
4.9 Connecting the AC Power
4.10 Connecting the Telephone Line
4.11 Completing the Operational Verification and Installation Checklist
4.12 Calibrating the Nephelometer
4.13 Site Documentation
4.14 Photographic Documentation
4.15 Operator Training
4.16 Completing Routine Site Maintenance

4.1 SITE PREPARATION AND COMMUNICATION

Prior to any installation visit:

- Review the determined site preparation and installation requirements with the local contact.
- Schedule all site preparation activities.

- Maintain communications with the local contact during site preparation. Verify that all required site preparation is completed prior to the installation.

- Document the primary site operator(s) and backup operator(s).

- Obtain permission from private and public landowners to access the monitoring location for installation training.

- Schedule the site installation visit and operator training session.

- Arrange for any necessary installation assistance, as well as tools and/or equipment (e.g., shovels, wheelbarrow, etc.).

Once on site:

- Inspect any site preparation that has been done.

- Verify that all shipped items have arrived in good condition.

- Verify the proposed installation configuration and scheduling for the operator training session with on-site personnel.

4.2 INSTALLING THE TOWER

Nephelometer system components are typically mounted on a 4 meter (14 foot) Rohn type-25 tower. Installation of the tower is described below and illustrated in Figure 4-1, Nephelometer Tower Components.

BASE PLATE — The tower base plate may be buried 6 to 12 inches or placed at ground level and staked with 2-foot construction stakes. The base plate must be oriented so that one face of the tower faces north.

TOWER ORIENTATION — The Rohn tower is triangular. The tower must be installed with one face oriented to true north. The nephelometer will be mounted on this northward face.

GUY WIRES — The tower is typically supported by three (3) guy wires. The type of guy wire anchors used depends on the type of ground at the site:

- Sand or loose soil - screw stakes or stakes with welded plate

- Rock - construction stakes driven into pre-drilled holes or rock anchors with eye-screws.

The guy wires attach to the top of the tower by looping over the extending tower posts and to ground stakes by connection to turnbuckles on the stakes. The guy wires must be adjusted so the tower does not move and is plumb in all directions.

The tower must be rigidly mounted before other system components are attached.

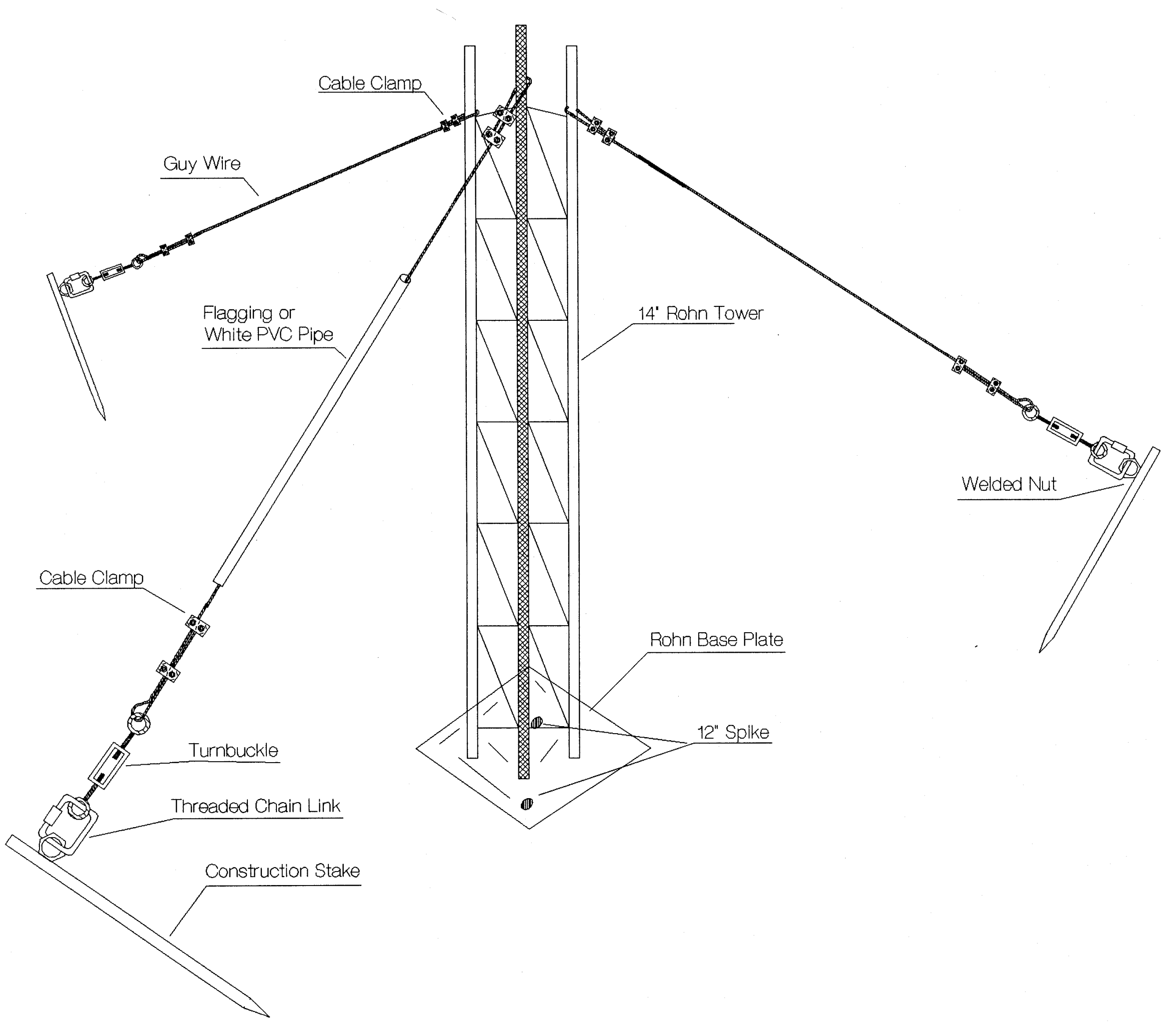

Figure 4-1. Nephelometer Tower Components.

4.3 INSTALLING THE SOLAR RADIATION AND PRECIPITATION SHIELD

The solar radiation and precipitation shield provides the following functions:

- Supports the nephelometer (the shield has mounting bolts and an integrated pulley system to accommodate easier installation and removal of the nephelometer)
- Protects the nephelometer from severe precipitation (rain, hail, etc.)
- Protects the nephelometer from direct solar radiation to maintain the instrument as close to ambient temperature as possible

The shield must be assembled before installation on the tower as described below and illustrated in Figure 4-2, Solar Radiation and Precipitation Shield Assembly.

ASSEMBLE THE FRAME AND ROOF	Assemble the solar radiation and precipitation shield frame on the ground before attaching the frame to the tower. Note that the roof of the frame slants toward the back (tower side) of the frame to drain precipitation toward the rear of the shield. Do not attach the rear baffles to the frame at this time.
MOUNT FRAME TO TOWER	Mount the frame to the north face of the tower and near the top so the roof just touches the guy wires. Use the supplied U-bolts to attach the frame to the tower.
ATTACH REAR BAFFLES TO FRAME	Attach the rear baffles to the frame after mounting the frame to the tower. The baffles keep direct sun from heating the nephelometer, yet allow air flow to the instrument.

4.4 INSTALLING THE PRECIPITATION HOOD

The precipitation hood fits over the front (door side) of the nephelometer and is held in place by the nephelometer top mounting studs and the front feet. Installing the hood to the nephelometer is described below and illustrated in Figure 4-3, Precipitation Hood Installation Diagram.

REMOVE NEPHELOMETER	Remove the nephelometer from the mounting bars of the existing precipitation/solar radiation shield and carefully lower the instrument to ground level using the rope and pulley system on the precipitation and solar radiation shield.
REMOVE FRONT FEET	Remove the two front feet of the nephelometer by removing the flat head bolts under the feet. Set the feet and feet bolts aside, they will be reattached later.
MOUNT HOOD TO NEPHELOMETER	Carefully slide the precipitation hood over the front of the nephelometer, making sure the top slits in the hood are aligned with the top mounting studs on the nephelometer. Slide the hood over the nephelometer until the backs of the slits of the hood meet the nephelometer mounting studs. Align the mounting holes on the bottom of the hood with the feet bolt holes. The hood is designed to fit tightly so some adjustment may be required.

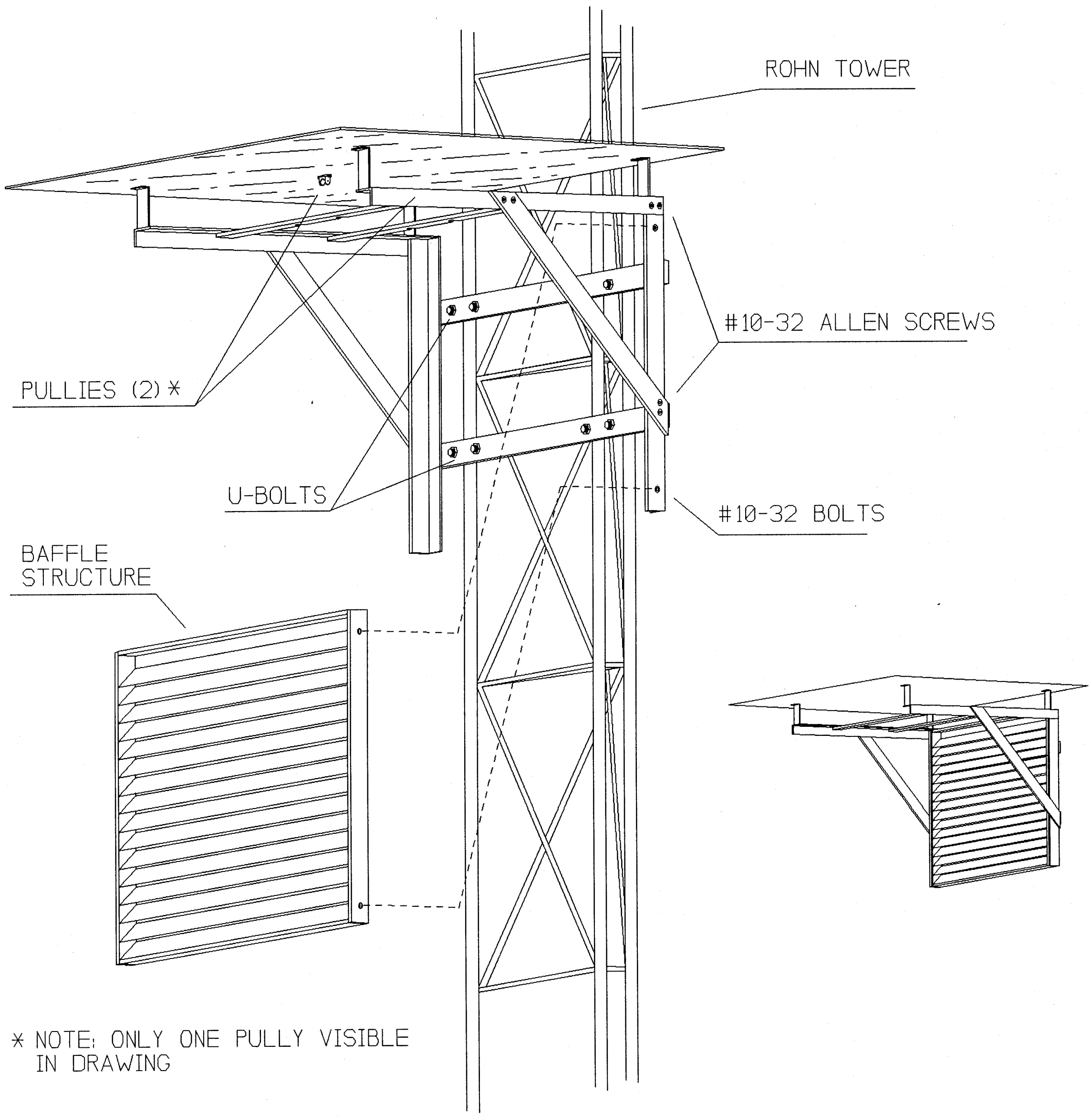

Figure 4-2. Solar Radiation and Precipitation Shield Assembly.

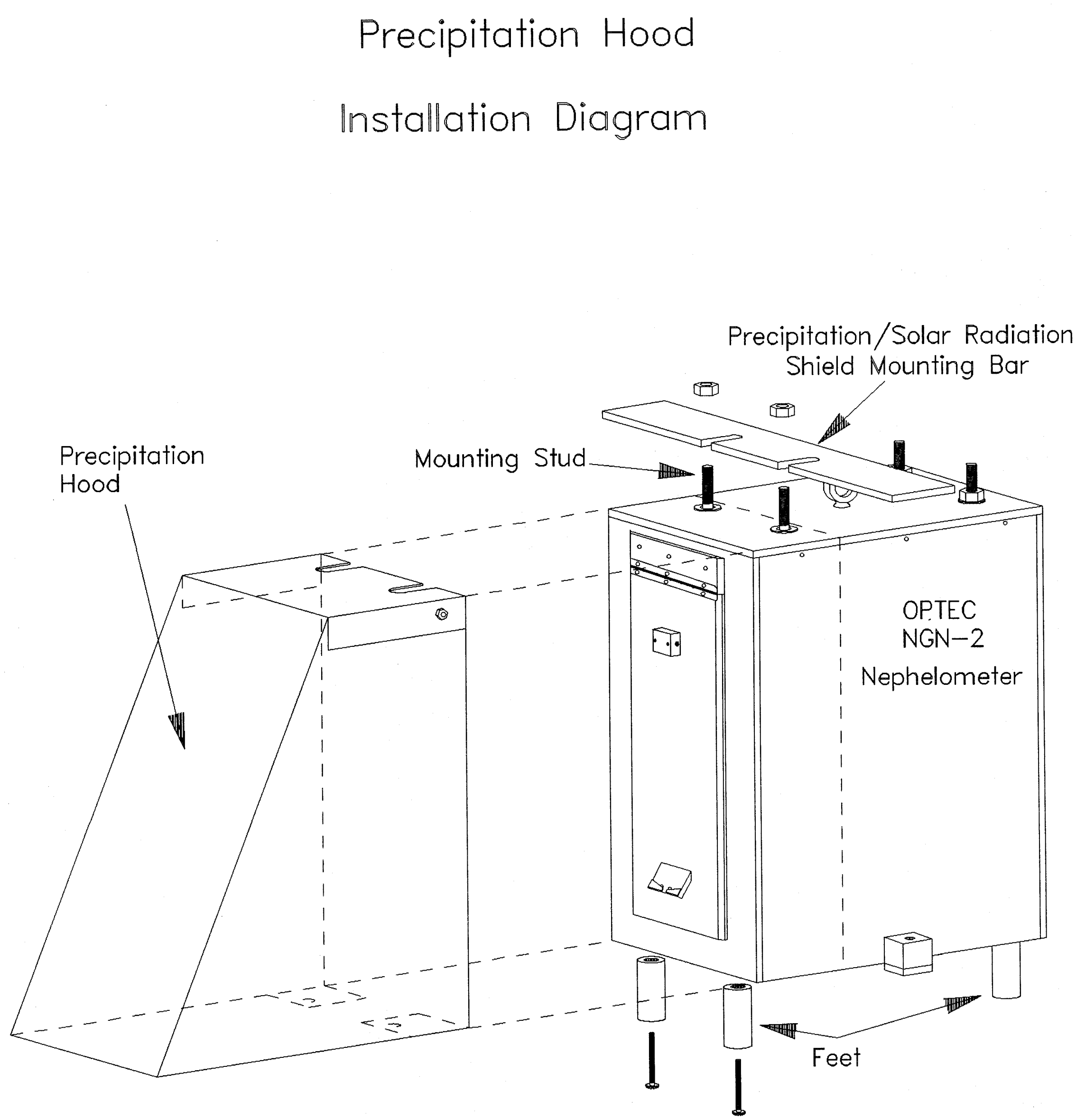

Figure 4-3. Precipitation Hood Installation Diagram.

ATTACH FRONT FEET	Reattach the two front feet to secure the bottom of the hood to the bottom of the nephelometer. The feet will temporarily hold the hood in place. Do not tighten the top mounting stud nuts.

4.5 INSTALLING THE NEPHELOMETER

Leave the nephelometer in the shipping case or box until at the site. Nephelometer installation procedures are detailed in TI 4100-3375, *Replacing and Shipping Nephelometer System Components,* and are summarized below:

UNPACK NEPHELOMETER EQUIPMENT	Carefully unpack the nephelometer and remove it from the shipping case or box.
ATTACH HOISTING ROPE	Feed the hoist rope through the two (2) pulleys on the underside of the precipitation and solar radiation shield (see Figures 4-2 and 4-3). Attach the nephelometer hoist rope attachment ring to the circular ring on top of the nephelometer (see Figure 4-4, Nephelometer Exterior Diagram).

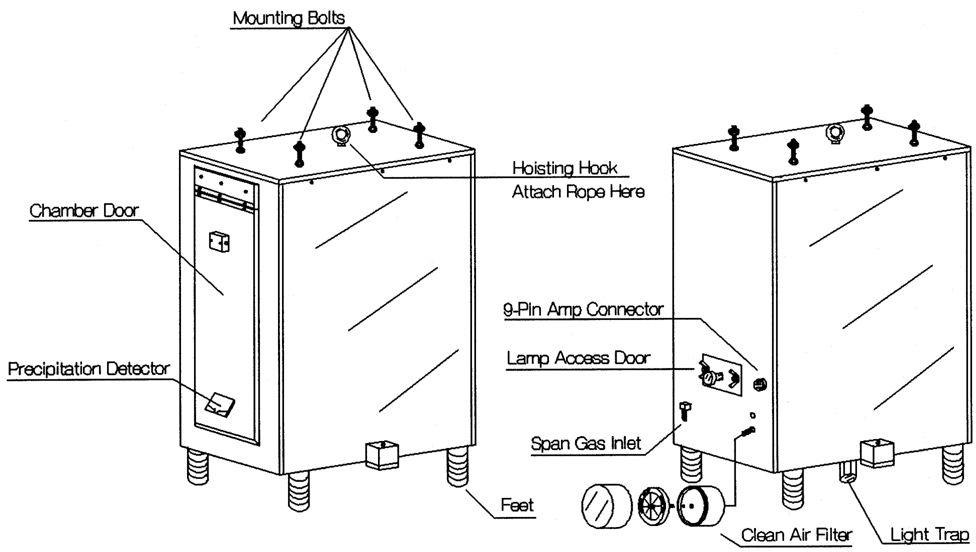

Figure 4-4. Nephelometer Exterior Diagram.

LOOSEN MOUNTING NUTS	Loosen but do not remove, the four (4) mounting nuts on the top of the nephelometer.
RAISE NEPHELOMETER	Use the rope and pulley system to raise the nephelometer to the precipitation and solar radiation shield.
SECURE ROPE TO TOWER	TIE THE ROPE SECURELY TO THE TOWER NEAR THE GROUND so that the nephelometer is suspended under the mounting bracket of the precipitation and solar radiation shield.

POSITION NEPHELOMETER

Carefully slide the nephelometer top studs into the shield mounting slits, making sure that the top of the hood fits under the front shield mounting bar, and that the mounting nuts fit over the shield mounting bar. Verify that the hood is pushed fully against the nephelometer top studs. Tighten the two front stud mounting nuts down onto the shield mounting bar to secure both the nephelometer and hood. Tighten the rear stud mounting nuts.

4.6 INSTALLING THE DATALOGGING AND CONTROL SUBSYSTEM

Leave the datalogging and control subsystem in the shipping case or box until at the site. The support system is generally mounted on the north face of the tower above the highest expected snow level. Detailed installation procedures are provided in TI 4100-3375, *Replacing and Shipping Nephelometer System Components*, and are summarized below:

UNPACK SYSTEM

Leave the datalogging and control subsystem in the shipping case or box until at the site.

Carefully unpack the system.

Open the enclosure and remove packing material from any internal components secured for shipping. The following items may require unpacking:

- Campbell datalogger
- Campbell storage module
- Campbell modem
- AC surge protector
- Other loose components

CHECK COMPONENTS

Verify that all components in the enclosure are positioned properly (see Figure 4-5, Datalogging and Support Subsystem Component Diagram).

Check for loose wiring in the enclosure, especially on the datalogger terminal strips and interface circuit board.

ATTACH ENCLOSURE TO TOWER

Attach the enclosure to the tower mounting brackets using the four (4) bolts provided.

Attach the enclosure mounting brackets to the tower using the four (4) U-bolts provided.

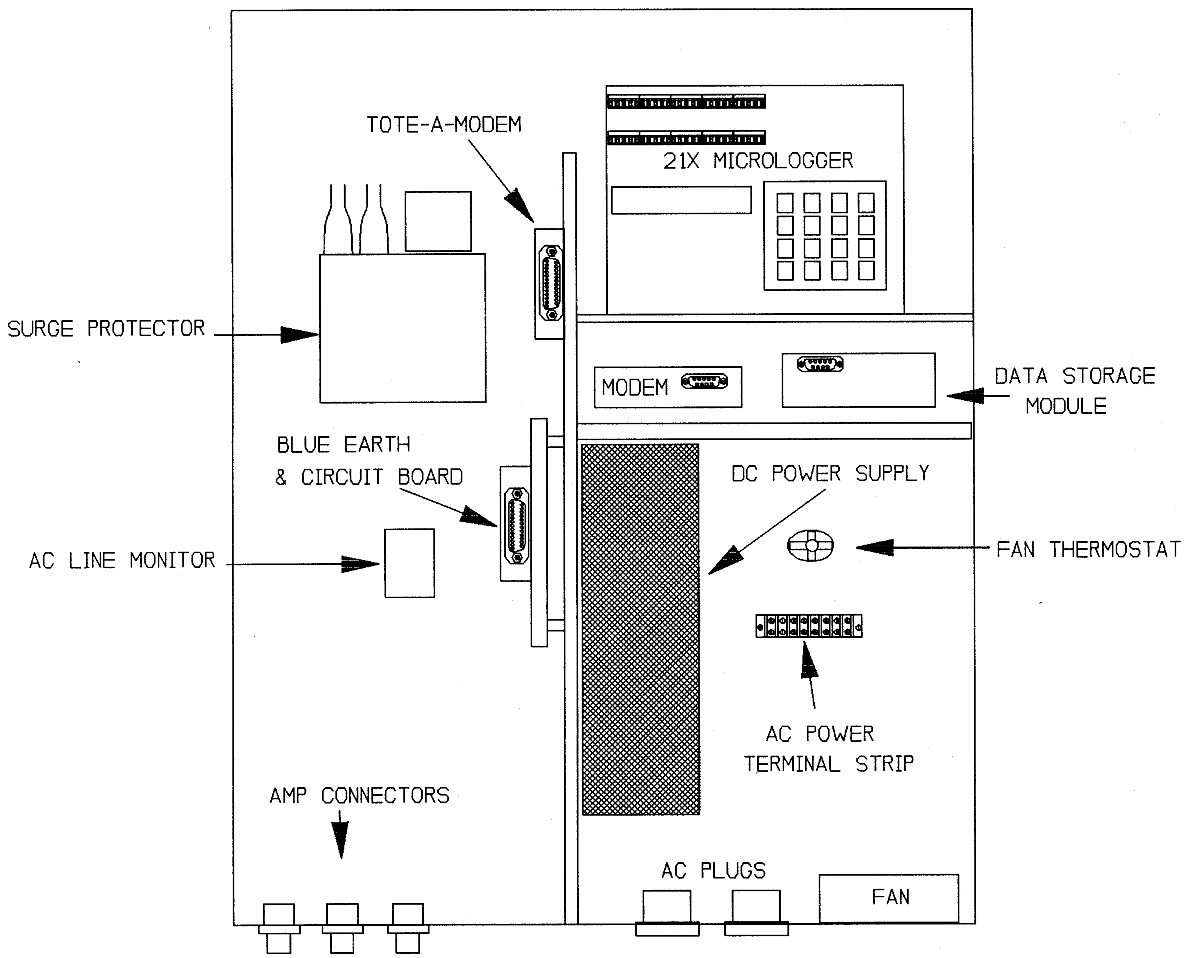

Figure 4-5. Datalogging and Support Subsystem Component Diagram.

CONNECT CABLES

Connect the following cables to the connector panel on the bottom outside of the enclosure after inspecting each connector for dust and debris. Figure 4-6, Datalogging and Control Subsystem Connector Panel Diagram (Viewed From Inside the Enclosure), and Table 4-1, Datalogging and Control Subsystem Connector Panel Description, describe the connectors on the subsystem:

- AC power
- Nephelometer power/signal
- AT/RH sensor with fan power
- Telephone line
- Terminal

TURN ON POWER

Turn on or plug in the main AC power supply to the enclosure.

VERIFY OPERATION

Verify correct operation of the datalogging system (refer to TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol))*.

4.7 INSTALLING THE ROTRONICS AT/RH SENSOR AND FORCE-ASPIRATED SHIELD

The Rotronics AT/RH sensor in its force-aspirated shield is mounted to the tower with the air inlet at the bottom of the shield at the same level as the center of the nephelometer intake screen. The +12 VDC power for the aspiration fan and power and signal wires for the sensor come from the datalogging and control subsystem through a pair of attached cables. Figure 4-7 is an illustration of the sensor and shield. The following procedures describe the installation of the sensor and shield:

ATTACH SHIELD TO TOWERt

Attach the force-aspirated shield to the tower using the L-bracket and U-bolts. The air inlet at the bottom of the shield must be at he same level as the center of the nephelometer intake screen.

ATTACH TO POWER CABLE

Attach the aspiration fan power connector to the power cable after inspecting for dust and debris within the two connectors. Clean the connectors if needed.

ATTACH SENSOR

Slide the sensor into the shield and tighten the securing screw.

Attach the sensor to the signal cable after inspecting for dust and debris within the two connectors. Clean the connector if needed.

CHECK SIGNAL POWER

Check that the signal power connector is connected to the datalogging and control subsystem. Refer to Figure 4-6 and Table 4-1 for datalogging and control subsystem connector information.

VERIFY OPERATION

Verify sensor and aspiration fan operation.

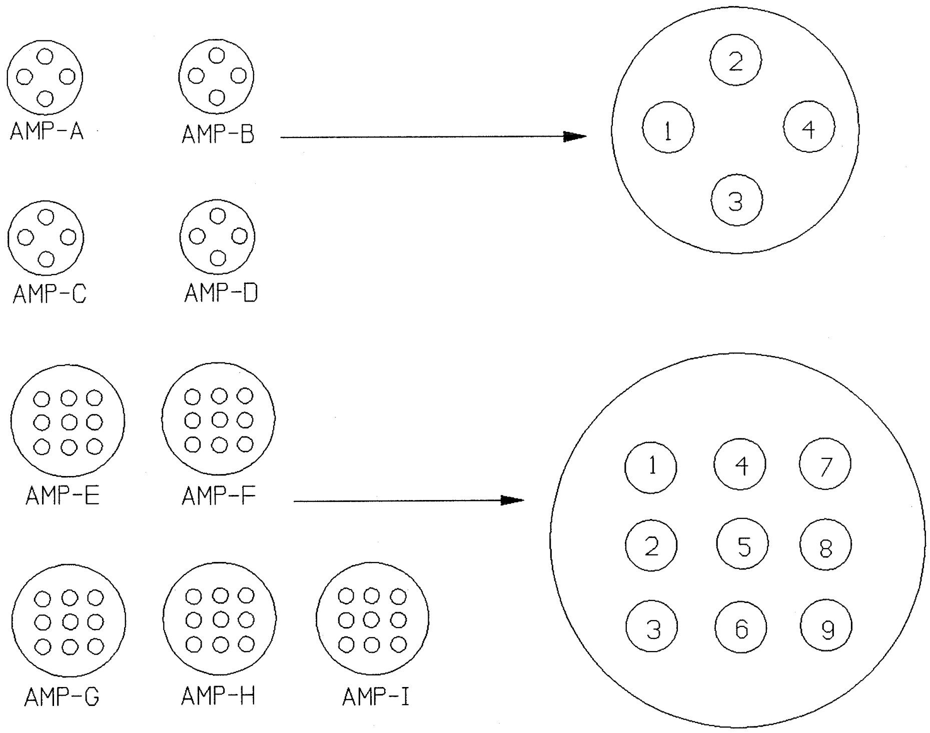

Figure 4-6. Datalogging and Control Subsystem Connector Panel Diagram (Viewed From Inside the Enclosure).

Table 4-1

Datalogging and Control Subsystem Connector Panel Description

Connector	Function
A	Terminal
B	Not used
C	Telephone line
D	Not used
E	Not used
F	Not used
G	Not used
H	Rotronics AT/RH and fan
I	Nephelometer

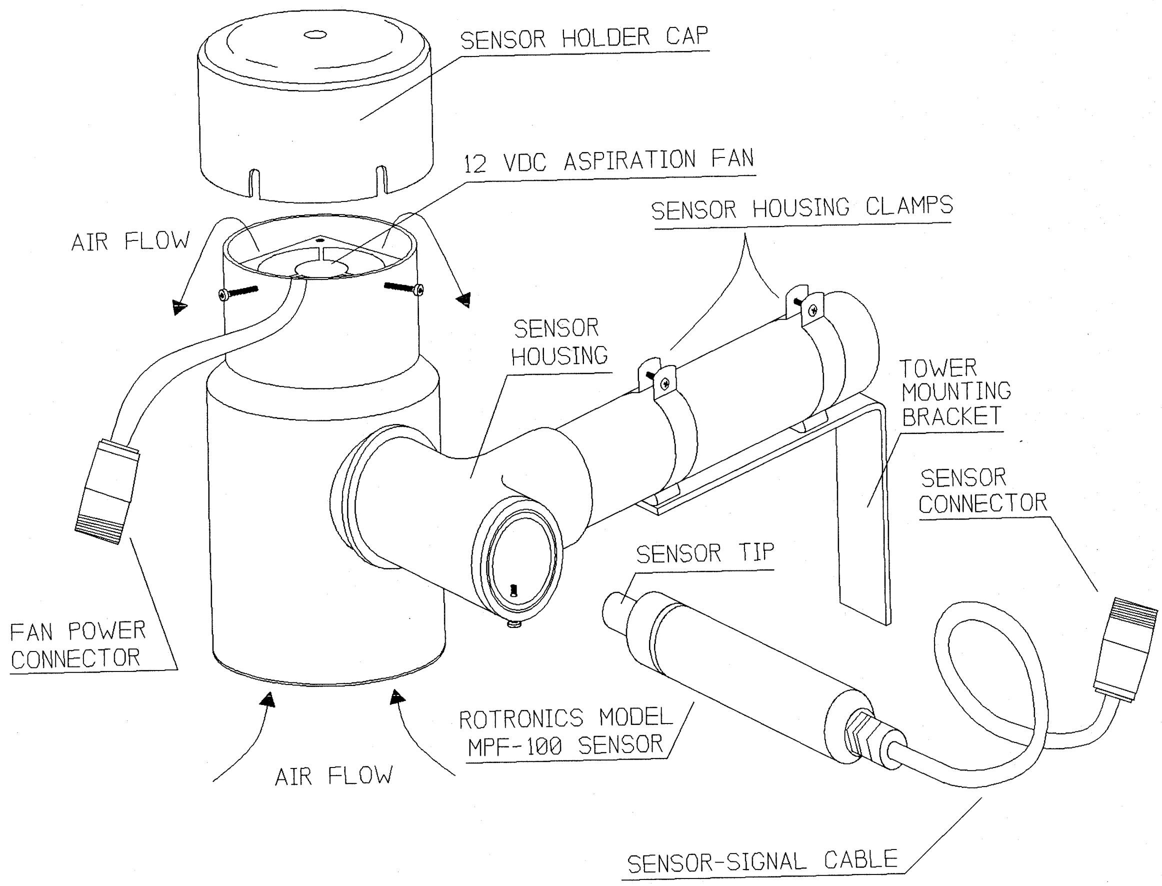

Figure 4-7. Rotronics AT/RH Sensor in Force-Aspirated Shield.

4.8 INSTALLING THE SPAN GAS CALIBRATION SYSTEM

The span gas calibration system is used by the site operator to perform scheduled span and zero calibration checks of the nephelometer. The system, illustrated in Figure 4-8, includes the following components:

- Span gas enclosure
- Span gas regulator
- Span gas rotameter with enclosure
- Span gas hoses
- Suva 134-A span gas tank

The span gas calibration system is typically attached to the tower as described below:

ATTACH THE SPAN GAS ENCLOSURE	Attach the span gas enclosure to the tower at the same level as the datalogging and control subsystem using the supplied mounting blocks and U-bolts.
ATTACH THE ROTAMETER ENCLOSURE	Attach the rotameter enclosure to the tower at a height of approximately five (5) feet (comfortable viewing level) using the supplied U-bolts (refer to Figure 4-8).
ATTACH THE SPAN GAS HOSES	Attach one end of the long span gas hose to the nephelometer span gas inlet. Attach the other end of the long span gas hose to the rotameter outlet fitting on the back of the rotameter enclosure. Attach one of the short span gas hoses from the rotameter inlet fitting to the outlet of the pressure regulator. Finally, connect the remaining short length of span gas hose from the outlet of the span gas tank to the inlet of the pressure regulator. Carefully tighten all connections slightly with pliers.

4.9 CONNECTING THE AC POWER

The nephelometer is generally AC powered. The method for running AC power from the AC source to the nephelometer station varies from site to site and depends on the following:

- Distance from the AC source to the station
- Termination (type of connection) of the AC at the source
- Local requirements (conduit, conductor type, etc.)
- Ground type (soil, rock, etc.)

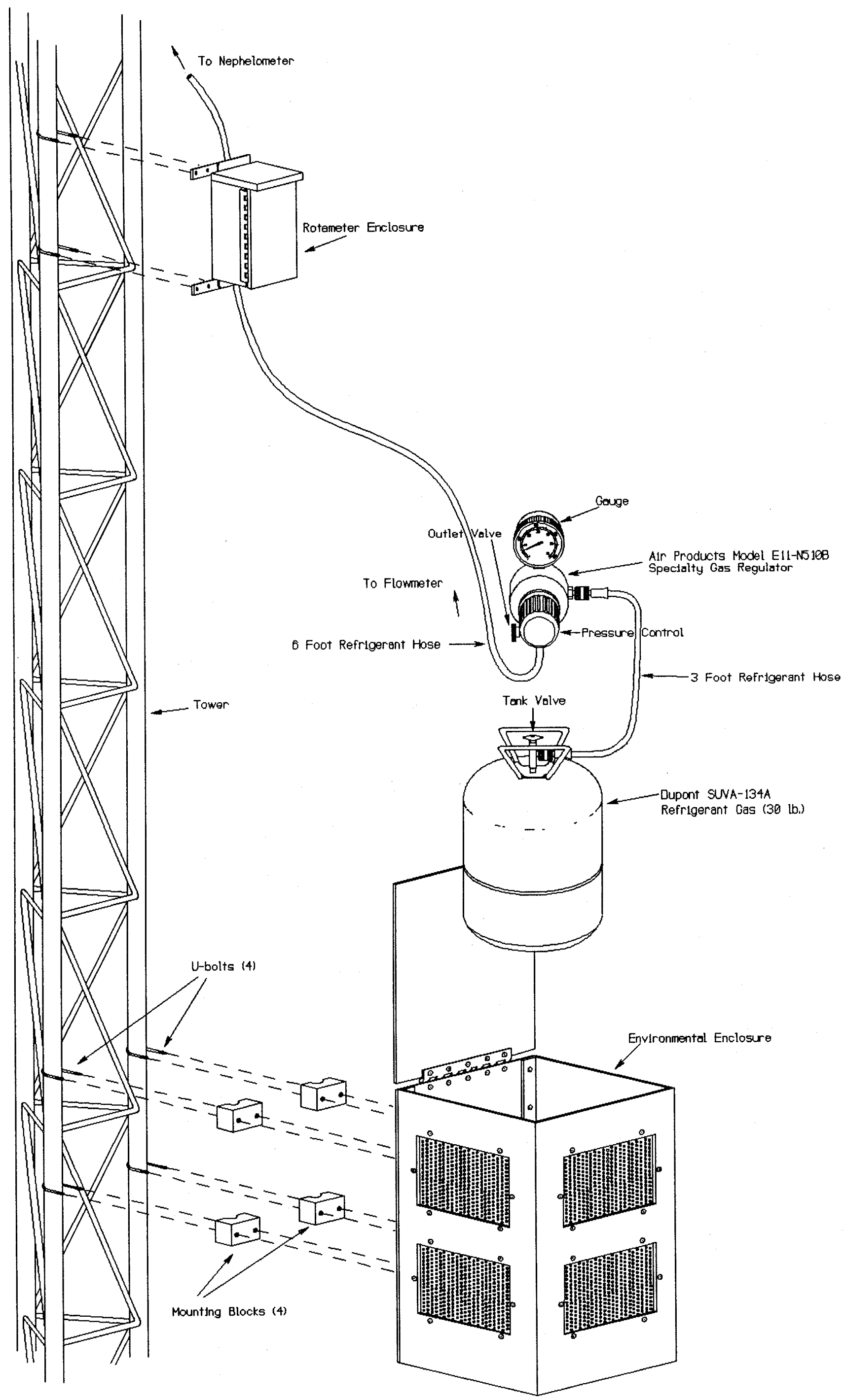

Figure 4-8. Span Gas Calibration System.

If the AC source is a standard wall outlet inside an aerosol IMPROVE shelter, the standard method for running the AC power line is as follows:

BURY PIPE — Bury 1" diameter PVC pipe or flexible cable conduit from the shelter to the tower.

RUN AC LINE — Run the AC line from an outlet in the shelter, through the pipe or conduit to the support system. Use a standard AC grounding plug inside the shelter and a female circular AR plug at the tower.

Other configurations may require assistance from a local electrician.

4.10 CONNECTING THE TELEPHONE LINE

Telephone communication with the nephelometer system through a standard telephone line is the preferred system configuration. If a standard telephone line is not available, cellular telephone options should be investigated. The following procedures describe a typical telephone installation assuming a standard line is available:

RUN PHONE LINE THROUGH PIPE — The telephone line is generally terminated in a standard telephone company Network Interface Box. Run the phone line through a buried PVC pipe or flexible conduit from the Network Interface Box to the tower. Depending on the location of the Network Interface Box, the phone line can be run through the same PVC pipe or conduit as the AC power.

ATTACH PHONE LINE — Attach the phone line to the red and green phone line termination screws in the Network Interface Box.

ATTACH AMP CONNECTOR — Attach a 4-pin female circular AMP connector to the end of the line near the tower. The wiring for this connector is detailed in TI 4100-3350, *NGN-2 Nephelometer Monitoring System Diagrams and Component Descriptions*.

If cellular telephone service is required, the following procedures apply:

MOUNT POWER SUPPLY — The cellular transceiver and power supply can be mounted in an enclosure on the tower or placed in a nearby shelter.

INSTALL ANTENNA — A directional antenna (Yagi type or similar) is preferred over an omni-directional antenna. The antenna should be installed on the tower or shelter and aimed at the cellular site (the location of the cellular site is available from the cellular service provider).

4.11 COMPLETING THE OPERATIONAL VERIFICATION AND INSTALLATION CHECKLIST

Major functions of the nephelometer system can be verified by performing a routine site visit as is detailed in TI 4100-3100, *Routine Site Operator Maintenance Procedures for NGN-2 Nephelometer Systems (IMPROVE Protocol)*. Routine site visit procedures include a simple nephelometer calibration.

The NGN-2 Nephelometer Installation Checklist (Figure 4-9), enables documentation of installation checks performed. The checklist covers the following areas and is described below:

- Site access information
- Site documentation photographs
- Datalogger program version and storage module type
- Interface circuit board functionality
- AC power connection description
- Datalogging and control subsystem power indicators
- Telephone line connection description
- Nephelometer calibration
- Rotronics AT/RH sensor check

SITE ACCESS INFORMATION — Document all locks (padlocks, gate locks, etc.) and other access requirements related to the site. Include lock type, manufacturer, ID number, and site personnel having responsibility for access.

PHOTOGRAPHS — Verify that required site photographs were taken (see Section 4.14).

DATALOGGER PROGRAM — Verify that the correct program is running in the datalogger and is stored in area #8 of the storage module. Record the datalogger program version and serial number of the storage module. Set the datalogger time to LOCAL STANDARD TIME.

INTERFACE CIRCUIT BOARD — Verify operation of the interface circuit board, including:

- Check Blue Earth indicator LEDs:

Color	Normal Status	Function
Red	ON	Power OK when ON.
Yellow	OFF	Receiving serial data from the nephelometer when ON.
Green	OFF	Transmitting data to the nephelometer when ON.

NGN-2 NEPHELOMETER INSTALLATION CHECKLIST

Site Name ________________________ Site Abbreviation __________________________

Date ________________ Local Time __________ ( ) Service Personnel _____________

Site Access Information

Document access requirements (locks and personnel) related to access to the site (type, manufacturer, ID number):

____

____

____

Photographs

Photograph the following:

Cardinal directions YES NO

Surrounding area YES NO

General nephelometer shots YES NO

Datalogger Program

21X program version: __________________ Is program in storage module? ________

Storage module currently installed: _____________________________

Time set to LOCAL STANDARD TIME on datalogger: YES NO

Interface Circuit Board

Blue Earth indicator LEDS? Red: ON OFF Yellow: ON OFF Green: ON OFF

Watchdog relay clicking? ON OFF

Toggle port #2 of the datalogger (*6A022) to reset the Blue Earth.

The Blue Earth should output a test sequence of:

1111 2222 3333 4444 5555 6666 7777 8888 9999 to the datalogger.

Examine datalogger locations 15-21 (*615AAA...).

Was the test sequence logged correctly? YES NO

Power Systems

Describe the AC power installation:

____

____

____

Are AC and DC indicator lamps operational? ____________ Fuses OK? __________

Record output of DC power supply (VDC): _______________________________

21X datalogger red LED on? YES NO

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(Nephinst.frm 6/96)

Figure 4-9. Nephelometer Installation Checklist.

NGN-2 NEPHELOMETER INSTALLATION CHECKLIST (CONT.)

Telephone Line

Describe the telephone line installation:

____

____

____

Nephelometer

Verify Power On Self Test functions.
Verify correct serial and analog updates to 21X datalogger:
Correct output code: YES NO
Ambient value reasonable: YES NO
Lamp value adequate: YES NO
Document span gas system in use at site: ____________________________________

Nephelometer Calibration

	Zero Span	Zero Span	Zero Span	Zero Span	Zero Span	Zero Span	Zero Span	Zero Span	Zero Span
Simple Calibration									
Complete Calibration									

Rotronics AT/RH Sensor

Reference AT/RH sensor: Model ________ S/N ________ Last Calibration: _________

Use the reference sensor to check the operation of the on-site AT/RH sensor.
Record the following information from the reference sensor and 21X datalogger *6 locations:

Reference AT: ___________________ On-Site AT (*6,1): ____________
Reference RH: ___________________ On-Site RH (*6,2): ____________

(Nephinst.frm 6/96)

Figure 4-9. (Continued). Nephelometer Installation Checklist.

- Serial Test Sequence:

  Toggle port #2 of the datalogger (*6 A 0 2 2) to interrupt power to the Blue Earth.

  Examine datalogger locations 15-23 (*6 15 A A A ...). Verify that the following test sequence from the Blue Earth was logged correctly by the datalogger:

  1111 2222 3333 4444 5555 6666 7777 8888 9999

POWER SYSTEMS — Note any relevant details regarding the AC power connection to the station. Verify correct operation of the power systems by checking the following:

- Line on indicator lamp on the UPS should be "ON"
- AC and DC indicator lamps should be "ON"
- Correct fuses: 2-amp AC fuse and 7-amp DC fuse
- Output of DC power supply should be 13.8 VDC nominal
- Red LED on side of datalogger should be "ON" to indicate that the datalogger charger is operating

TELEPHONE LINE — Note any relevant details regarding the telephone line connection. Verify correct operation of telephone access to the station by having ARS call the site.

NEPHELOMETER CALIBRATION — Record the results of several simple and complete calibrations in the table.

ROTRONICS AT/RH SENSOR — Verify correct operation of the Rotronics AT/RH sensor by comparing the output to a reference sensor.

- Record the model, serial number, and date of last calibration of the reference sensor.
- Record collocated sensor readings of AT and RH from the reference sensor and the on-site sensor.

4.12 CALIBRATING THE NEPHELOMETER

Calibrating the nephelometer is performed after all components have been installed and their correct operation verified. Several manual and automatic calibrations must be performed according to the following documentation:

- SOP 4200, *Calibration of Optical Monitoring Systems (IMPROVE Protocol)*
- TI 4200-2000, *Calibration of Optec NGN-2 Nephelometers (IMPROVE Protocol)*

Document all calibration results and provide the results to the data analyst.

4.13 SITE DOCUMENTATION

Site documentation for Optec NGN-2 nephelometer stations is described in TI 4070-3001, *Site Documentation for Optec NGN-2 Nephelometer Systems*. The site documentation form in TI 4070-3001 must be completed and provided to the data analyst after initial installation of a nephelometer system.

4.14 PHOTOGRAPHIC DOCUMENTATION

Photographic documentation is detailed in TI 4070-3001. Photographs provide an important record of the installation, especially for personnel unfamiliar with the site. The following list summarizes the required photographs:

- Cardinal directions from the tower (North, East, South, West)
- Detailed installation close-ups of telephone and AC wiring
- Photographs of any local sources or obstructions to air flow to the station
- Landmarks necessary to locate the site
- Photographs of the station from several viewpoints and directions
- Other detailed close-ups

4.15 OPERATOR TRAINING

Training the site operator is detailed in TI 4115-3005, *Annual Site Visit Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*. Simultaneous training of primary and backup operators, as well as supervisors involved in the program is preferred. Training typically includes the following:

- Overview of the IMPROVE Program
- Overview of visibility (extinction, scattering, transmissometers, nephelometers, particle samplers, cameras)
- Nephelometer functional description and simplified theory of operation
- Nephelometer calibration (purpose and frequency)
- Nephelometer station component functional overview
- Detailed description of datalogger access
- Basic troubleshooting techniques
- Completion of the NGN-2 Nephelometer/Meteorology Log Sheet
- Operator questions

4.16 COMPLETING ROUTINE SITE OPERATOR MAINTENANCE

Routine site operator maintenance is performed by the field specialist as the last step of the installation visit. The procedures are detailed in TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*. Provide completed log sheets and other documentation to the data analyst.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**SITE DOCUMENTATION FOR OPTEC NGN-2 NEPHELOMETER SYSTEMS**
TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4070-3001**
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AUTHORIZATIONS		
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REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes site documentation for Optec NGN-2 nephelometer sites operated according to IMPROVE Protocol. The purpose of this TI is to assure quality data capture and minimize data loss by:

- Performing thorough on-site specification measurements.
- Documenting site specification measurements and other site-related information.

These site documentation procedures shall be completed upon any of the following:

- Installation or removal of the nephelometer station
- Change in location of the station
- Significant change(s) to the information included on the form

This TI is referenced from Standard Operating Procedure (SOP) 4070, *Installation and Site Documentation for Optical Monitoring Equipment*.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall review the completed NGN-2 Nephelometer Site Documentation Form(s) for completeness and accuracy.

2.2 FIELD SPECIALIST

The field specialist shall:

- Complete the NGN-2 Nephelometer Site Documentation Form upon installation, removal, or movement of the nephelometer station.
- Provide completed site documentation to the data analyst.

2.3 DATA ANALYST

The data analyst shall:

- Enter all site documentation into the Quality Assurance Database.
- File all hard copy site documentation provided by the field specialist.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The following equipment and materials are required for nephelometer site documentation:

- NGN-2 Nephelometer Site Documentation Form

- Pen or pencil
- Camera loaded with color print film
- Topographic maps of the area

4.0 METHODS

Site documentation of NGN-2 nephelometer stations includes completion of the NGN-2 Nephelometer Site Documentation Form. Information required regarding site documentation is detailed in the following subsections:

4.1 Location
4.2 Geographic Reference
4.3 Equipment Documentation
4.4 Meteorology and Climatology
4.5 General Comments and Additional Information
4.6 On-site Equipment Inventory

Figure 4-1 (presented at the end of this section) is an example NGN-2 Nephelometer Site Documentation Form.

4.1 LOCATION

Completion of Section I: Location, of the NGN-2 Nephelometer Site Documentation Form is detailed below.

SITE NAME, DATE, FORM COMPLETED BY	Record the full site name, including the type of site (e.g., national park, etc.), the date the form was completed, and the name of the person completing the form.
SITE ABBREV-IATION AND VERIFICATION	Record the four (4) character site abbreviation and the name of the person verifying the contents of the form.
SITE MAILING ADDRESS AND SHIPPING ADDRESS	Record the site mailing address, the address to which correspondence is sent via US Mail. Record the shipping address, the address to which UPS can deliver parcels. The shipping address cannot be a post office box.
NETWORK	Record the network name (e.g., IMPROVE).
SITE CONTACTS AND OPERATOR	Record the name, telephone, and fax numbers for any site operator(s), contact(s), and supervisor(s).
DATA RETRIEVAL PHONE NUMBER	Record the telephone number used to access the nephelometer station data collection modem if the station is so equipped.
INSTALLATION DATE	Record the date and time the nephelometer station was installed.

INSTALLED BY	Record the name of the person(s) who installed the station.
BEGINNING DATE	Record the date and time the nephelometer became operational.

4.2 GEOGRAPHIC REFERENCE

Completion of Section II: Geographic Reference, of the NGN-2 Nephelometer Site Documentation Form is detailed below.

GENERAL SITE DESCRIPTION	Record any information that describes the general condition and layout of the site.
ELEVATION AND RAYLEIGH COEFFICIENT	Record the elevation at ground level in meters of the station using the best available source (map, altimeter, etc.). Record the method used to determine the elevation. Record the Rayleigh coefficient for the station elevation.
INLET AND SENSOR HEIGHTS	Record the nephelometer inlet and AT/RH sensor inlet heights above ground level in meters.
COORDINATES	Record the coordinates (latitude and longitude) of the station in the following ways: • Degrees, minutes, and seconds • Decimal degrees • UTM zone, easting, and northing
MAP REFERENCES	Record references from any maps available and/or used to complete this form. Note the map name, scale, and source of the map.
MAP SKETCH	Sketch a map to document the environment within 1/2 km radius of the site. Indicate trees, buildings, bodies of water, roads, parking areas, etc.
DOMINATING INFLUENCES	Document any dominating point, area, and mobile pollutant influence on the site. List the source and pollutant.
LAND USE BY TYPE	Document the type of land use within 1/2 km of the site by distance and direction. The following land use types are included: • Urban Land Use: - Residential - Commercial - Industrial

- Mobile
- Other (describe)

• Non-Urban Land Use:

- Agricultural
- Forest
- Desert
- Residential
- Mobile
- Other (describe)

LAND USE BY DIRECTION — Document the type of land use within 2-3 km of the site by direction. The land use types are listed above.

PHOTOGRAPHS — Attach separate photographs (3" x 5" color prints preferred) of:

• Site installation from various angles that document all site components.

• Cardinal direction views from the installation (N,E,S,W).

TOPOGRAPHY — Document the general characteristics of the terrain (smooth, rolling, or mountainous) over a 3 km radius from the site.

Document the type, size, direction, and distance from the site of the topographic features that influence the site, including:

• Hills
• Valleys
• Depressions
• Bodies of water
• Ridges
• Cliffs
• Other (describe)

OBSTRUCTIONS — List the type, size, direction, and distance from the site of any obstructions that could influence the site, including any of the following:

- Buildings
- Trees
- Ridges
- Cliffs
- Other (describe)

4.3 EQUIPMENT DOCUMENTATION

Completion of Section III: Equipment Documentation, of the NGN-2 Nephelometer Site Documentation Form is detailed below.

NETWORK — Record the network name, (e.g., IMPROVE).

SAMPLE FREQUENCY — Document the sampling frequency of the nephelometer and AT/RH sensors (e.g., usually 5 minutes for IMPROVE Protocol sites).

SITE CONFIGURATION — Describe the site configuration, including instrumentation.

POWER — Document the availability and location of AC and DC power.

DATALOGGER TYPE — Document the following:

- Type of primary datalogger
- Type of telephone modem and telephone number
- Type of DCP
- DCP transmission information, including ID, channel, frequency, and transmit time
- Other (specify)

COLLOCATED EQUIPMENT — Describe any collocated air quality and/or meteorological monitoring equipment, including:

- Type
- Description
- Parameters measured
- Distance from nephelometer station
- Sample height in meters above ground level

LOCAL UTILITIES	Record the address, telephone number, and any contacts for the local telephone and electric utilities.

4.4 METEOROLOGY AND CLIMATOLOGY

Completion of Section IV: Meteorology/Climatology, of the NGN-2 Nephelometer Site Documentation Form is detailed below.

CLIMATE	Document minimum, maximum, and average temperature and precipitation for the following periods: • Annual • Winter • Spring • Summer • Fall
BAROMETRIC PRESSURE	Document the name, code, elevation, and any comments for the three (3) nearest reporting weather stations that collect barometric pressure.

4.5 GENERAL COMMENTS AND ADDITIONAL INFORMATION

Completion of Section V: General Comments, Notes, or Additional Information, of the NGN-2 Nephelometer Site Documentation Form may include any or all of the following:

- Maps
- Drawings
- Statistics
- Other (describe)

4.6 ON-SITE EQUIPMENT INVENTORY

Completion of Section VI: On-site Equipment Inventory, of the NGN-2 Nephelometer Site Documentation Form, will ensure that all equipment is properly accounted for. All on-site equipment should be itemized in Section VI. Identify and list each component, including the manufacturer's name, stock number, model number, serial number, property number, and any other information necessary to properly inventory the equipment. The information provided in Section VI will serve as the primary reference for data entry into the project-specific inventory database. If detailed packing lists, inventory database printouts, or other information exist that fully describe the on-site equipment, verify this information and attach to Section VI.

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NGN-2 NEPHELOMETER SITE DOCUMENTATION FORM

I.	**LOCATION**	Date:	
1.	Site Name:	Form Completed by:	
2.	Site Abbreviation:	Verified by:	
3.	Site Mailing Address:	Site Shipping Address: (if different):	
4.	Network:		
5.	Site Contacts: Name Telephone Fax		
	Site Operator:		
	Supervisor:		
6.	Data Retrieval Phone No.		
7.	Installation Date:		
8.	Installed By:		
9.	Beginning Date of Operational Data Collection: Date: Time:		
II.	**GEOGRAPHIC REFERENCE**		
1.	General Site Description:		
2.	Elevation at Ground Level (m)	Rayleigh Coefficient: (km^{-1})	
3.	Nephelometer Inlet Height (agl): (m)	AT/RH Sensor Height (agl): (m)	
4.	Coordinates D M S	Decimal Degrees	UTM
	Longitude: : :		Zone:
	Latitude: : :		East:
			North:
5.	Map References:		

Figure 4-1. NGN-2 Nephelometer Site Documentation Form.

6.	Sketch a Map to Document the Environment Within a 1/2 km Radius of the Site (trees, buildings, bodies of water, roads, parking areas, etc.)	
7.	Dominating Influence of Site (indicate pollutant)	
	Point:	
	Area:	
	Mobile:	
8.	Land Use Within 1/2 km Radius From the Site:	
	Urban	Distance and Direction From Site
	Residential	
	Commercial	
	Industrial	
	Mobile	
	Other (describe)	
	Non-Urban	
	Agricultural	
	Forest	
	Desert	
	Residential	
	Mobile	
	Other (describe)	
9.	Predominant Land Use by Direction (2 to 3 km from the site; residential, commercial, industrial, suburban, urban, forest, etc.)	
	N:	
	NE:	
	E:	
	SE:	
	S:	
	SW:	
	W:	
	NW:	

Figure 4-1. (Continued). NGN-2 Nephelometer Site Documentation Form.

10. Attach Separate Photographs of:

a. Site Installation

b. Cardinal Direction Photographs From Installation (N,E,S,W)

11. Topography

a. The General Characteristics of the Terrain Over a 3 km Radius From the Site are (check one): _____ Smooth _____ Rolling _____ Mountainous

b. Topographic Features That Influence the Site (Types: hills, valleys, depressions, bodies of water, ridges, cliffs, etc.):

Type	Size	Direction From Site	Distance From Site

12. Obstructions

List Obstructions and Complete Information (Types: buildings, trees, ridges, cliffs, etc.):

Type	Size	Direction From Site	Distance From Site

III. EQUIPMENT DOCUMENTATION

1. Network:
2. Sample Frequency:
3. Site Configuration Description:
4. Power
   a. AC Line Power:
   b. DC Solar Power:
5. Datalogger Type: Phone No.
   a. Telephone/Campbell
   b. Synergetics DCP/Campbell
   c. Handar DCP/Campbell
   d. Other
   e. DCP Transmission Information

DCP Mfg.:	ID:	Channel:	Frequency:	XTM Time:

Figure 4-1. (Continued). NGN-2 Nephelometer Site Documentation Form.

6. Collocated Air Quality and/or Meteorology Monitoring Equipment

Type	Description/Parameters	Dist. From Neph (m)	Sample Height (agl)

7. Local Telephone Company	8. Local Power Company
Address:	Address:
Telephone:	Telephone:

IV. METEOROLOGY/CLIMATOLOGY

1. Climate

a. Temperature (C°)	Min.	Max.	Mean
Annual			
Winter			
Spring			
Summer			
Fall			

b. Precipitation (mm)	Min.	Max.	Mean	Type
Annual				
Winter				
Spring				
Summer				
Fall				

2. Nearest Regularly Reporting Weather Stations With Barometric Pressure

Name	Code	Elev.	Comments
a.			
b.			
c.			

Figure 4-1. (Continued). NGN-2 Nephelometer Site Documentation Form.

V. GENERAL COMMENTS, NOTES, OR ADDITIONAL INFORMATION

Figure 4-1. (Continued). NGN-2 Nephelometer Site Documentation Form.

VI. ON-SITE EQUIPMENT INVENTORY

Inventory Date: _________________

Performed By: ___________________

Item No.	Description	Stock No.	Model No.	Serial No.	Property No.	Comments

Figure 4-1. (Continued). NGN-2 Nephelometer Site Documentation Form.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**NEPHELOMETER MAINTENANCE (IMPROVE PROTOCOL)**
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REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) outlines and describes the components of a comprehensive program for operating and maintaining the Optec NGN-2 nephelometer. The purpose of this program is to provide detailed operations and maintenance procedures that will assure quality data capture and minimize data loss.

The NGN-2 nephelometer (Next Generation Nephelometer) is manufactured by Optec, Inc. and was first installed in 1993. The instrument has evolved to its present configuration through a series of laboratory tests and operational field trials designed to meet the needs of the National Park Service (NPS) Visibility Monitoring and Data Analysis Program and the Interagency Monitoring of Protected Visual Environments (IMPROVE) Committee, and other visibility monitoring programs.

The NGN-2 meets the following criteria:

- Measures atmospheric scattering both day and night at 550 nanometers.
- Provides a direct, unobstructed path from outside air to the measurement chamber.
- Operates with minimal modification to the temperature, relative humidity, aerosols, and gases of the sampled ambient air.
- Allows easy servicing and component replacement with its modular design.
- Operates at low power for remote solar power installation.
- Provides automatic clean air and span gas calibrations at user-selected intervals.
- Operates with minimal required servicing.

The NGN-2 uses a unique integrating open-air design that allows accurate measurement of the scattering extinction coefficient of ambient air. Because of the open-air design, relative humidity and temperature of the air sample are essentially unchanged, thus the aerosol is negligibly modified when brought into the optical measuring chamber. Extinction due to scatter can accurately be measured from Rayleigh to 100% saturated fog conditions.

Integrating nephelometers estimate the atmospheric scattering coefficient by directly measuring the light scattered by aerosols and gases in a sampled air volume. Scattered radiation from an illumination source is integrated over a large range of scattering angles, in a defined band of visible wavelengths. Because the total light scattered out of a path is the same as the reduction of light along a path due to scattering, the integrating nephelometer gives a direct estimate of b_{scat}.

An environmentally-sealed compartment in the unit contains the single board computer, lamp assembly, motors, pumps, and electronics. The single board computer controls all operating functions of the NGN-2 which include: scattered light measurement, clean-air zero calibration, span gas calibration, moisture detection to close the optical chamber door during rain or snow conditions, optical chamber temperature measurement, initial data reduction, various error detection schemes, and diagnostic tests.

The Optec NGN-2 operations and maintenance quality assurance program consists of three (3) major categories:

- Routine Site Operator Maintenance
- Annual Site Visit
- Annual Maintenance

Detailed descriptions of the procedures to be followed in performing specific maintenance tasks referenced in this SOP are provided in the following SOPs and technical instructions (TIs):

- TI 4100-3100 *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*
- TI 4100-3350 *NGN-2 Nephelometer Monitoring System Diagrams and Component Descriptions*
- TI 4100-3375 *Replacing and Shipping Nephelometer System Components*
- TI 4100-3400 *Nephelometer Annual Laboratory Maintenance (IMPROVE Protocol)*
- SOP 4115 *Annual Site Visits for Optical Monitoring Instrumentation (IMPROVE Protocol)*
- TI 4115-3005 *Annual Site Visit Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*
- SOP 4700 *Optec NGN-2 Nephelometer Audit Procedures (IMPROVE Protocol)*

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Oversee the activities of the data coordinator, instrument technician, and field specialist.
- Oversee and review site operator documentation.
- Oversee and review instrument maintenance records.
- Review routine maintenance and troubleshooting plans with the data coordinator, field specialist, and instrument technician as required.
- Review and approve any changes to maintenance procedures.

2.2 DATA COORDINATOR

The data coordinator shall:

- Coordinate site operator activities and schedules.
- Review site operator documentation.
- Provide technical support to the site operator.
- Coordinate replacement of malfunctioning equipment.
- Ship cleaning and other necessary supplies to the site operator.
- Document all communications with the site operator.
- Enter the results of all performed procedures into site-specific timelines.

2.3 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Perform annual servicing of transmissometers and associated support equipment.
- Repair damaged or malfunctioning nephelometers and associated support equipment.
- Maintain an inventory of spare parts and servicing supplies.
- Document all servicing and maintenance work.

2.4 FIELD SPECIALIST

The field specialist shall:

- Coordinate maintenance schedules with the project manager, data coordinator, and site operator.
- Provide technical support to the site operator.
- Perform field repair or replacement of nephelometer system components.
- Train the site operator in routine maintenance procedures.

2.5 SITE OPERATOR

The site operator shall:

- Coordinate the schedule and requirements for specific nephelometer component replacement and shipment procedures.
- Perform routine nephelometer system service and maintenance tasks.

- Document all on-site service and maintenance work performed.
- Report any problems immediately.
- Participate in site operator training sessions.

3.0 REQUIRED EQUIPMENT AND MATERIALS

ARS will maintain a sufficient inventory of spare components and repair parts to accommodate routine maintenance of the Optec NGN-2 nephelometer and associated support equipment. Required equipment and materials vary depending upon the servicing task, as detailed in the following subsections.

3.1 ROUTINE MAINTENANCE

Routine maintenance requires a small set of standard mechanical tools (screwdrivers, wrenches, etc.), fuses, a nephelometer lamp and clean air filter cartridge, and documentation supplies. A detailed list of equipment and materials for routine maintenance is provided in TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*.

3.2 ANNUAL LABORATORY MAINTENANCE

Annual laboratory maintenance requires specific instrumentation, including a digital voltmeter, dual channel oscilloscope, regulated power supply, optical laboratory equipment, an IBM PC-compatible computer terminal and circuit board test fixture, cleaning supplies, a small set of standard mechanical tools, and servicing forms and instrument manuals. A detailed list of equipment and materials for annual laboratory maintenance is provided in TI 4100-3400, *Nephelometer Annual Laboratory Maintenance (IMPROVE Protocol)*.

3.3 INVENTORY

It is imperative that all capital instrumentation changes made as a result of routine and annual maintenance be thoroughly documented and maintained in the ARS Purchase Order/Inventory Database. Specific model and serial number items tracked are discussed further in the maintenance TIs.

4.0 METHODS

This section includes five (5) major subsections:

4.1 Monitoring System Diagrams and Component Descriptions
4.2 Routine Site Operator Maintenance
4.3 Replacing and Shipping Components
4.4 Annual Site Visits
4.5 Annual Laboratory Maintenance

Each nephelometer site is supplied with a *Site Operator's Manual for Nephelometer Systems*. This manual contains SOPs and TIs applicable to site operator maintenance and manufacturer's instruction manuals for the NGN-2 nephelometer and associated support equipment.

4.1 MONITORING SYSTEM DIAGRAMS AND COMPONENT DESCRIPTIONS

Instrumentation at a typical IMPROVE network nephelometer site is shown in Figure 4-1 and generally includes:

- An Optec NGN-2 nephelometer.
- A gas calibration system.
- A datalogging and control subsystem.
- A shielded and aspirated Rotronics air temperature and relative humidity sensor.
- A support tower and related hardware.
- A precipitation and solar radiation shield.

The NGN-2 nephelometer outputs a two-minute integrated average value for measured ambient scattering at five-minute intervals. The on-site datalogger collects nephelometer data, along with instantaneous measurements of air temperature and relative humidity at five minute intervals. At site with telephone lines, the on-site datalogger is interrogated daily via telephone modem. At sites where telephone access is unavailable, preliminary data from the on-site datalogger are transmitted via GOES satellite and Handar data collection platforms (DCPs). Final data are retrieved from solid-state data storage modules. Clean air calibrations occur every six hours and automatic span calibrations and automatic tests occur at power-up. Complete descriptions of all nephelometer system components are provided in TI 4100-3350, *NGN-2 Nephelometer Monitoring System Diagrams and Component Descriptions*.

4.2 ROUTINE SITE OPERATOR MAINTENANCE

Routine site operator maintenance for the NGN-2 nephelometer should be performed weekly and includes the following general tasks:

- Inspecting the condition of all structural hardware, nephelometer components, support system components, and meteorological sensors
- Verifying power system status
- Checking system timing
- Initiating a zero and upscale/span calibration check
- Observing the Power-On Self Test (POST)
- Exchanging the data storage module
- Documenting system readings.

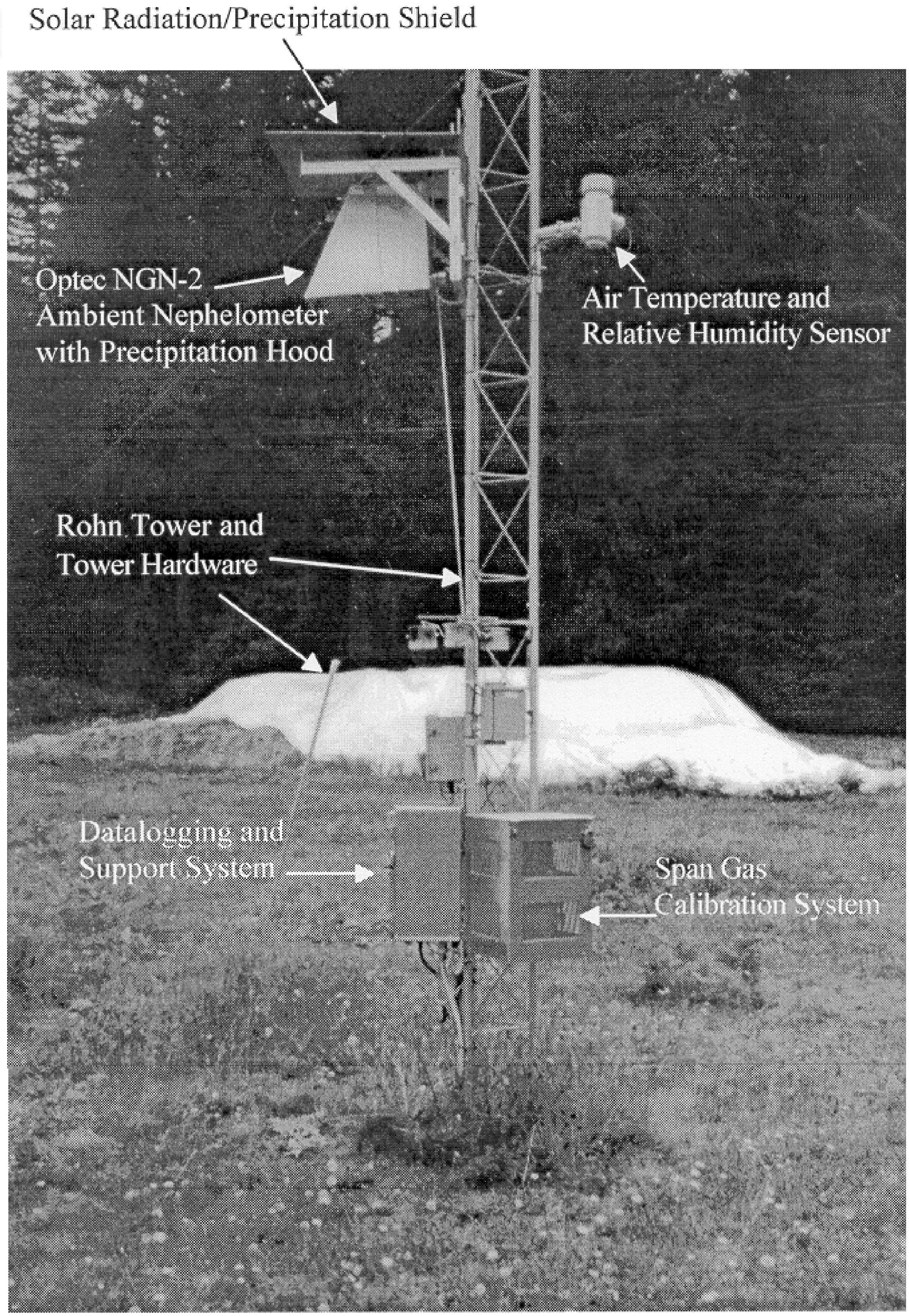

Figure 4-1. Typical Optec NGN-2 Nephelometer Station.

All observations and noted problems are documented on an NGN-2 Nephelometer/Meteorology Log Sheet. In most cases, site operators can diagnose and solve nephelometer system problems in the field. The majority of nephelometer problems are due to moisture in the nephelometer, lamp malfunction, electrical power outages or surges, and lightning induced voltage spikes. Detailed routine maintenance procedures are discussed in TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*.

4.3 REPLACING AND SHIPPING COMPONENTS

Periodic maintenance for the NGN-2 nephelometer is required when a malfunctioning unit or system must be replaced. System components that may require removal include the nephelometer, the data collection platform, the datalogging and control subsystem, and the air temperature/relative humidity sensor. Each component must be properly removed and packaged for shipping to prevent further damage. Detailed discussions regarding replacing each component are presented in TI 4100-3375, *Replacing and Shipping Nephelometer System Components*.

4.4 ANNUAL SITE VISITS

IMPROVE nephelometers operate in the field for a period of 12 months. An ARS field specialist annually visits each site and removes the "old" nephelometer and replaces it with a fully-serviced instrument. As a part of this annual site visit, the field specialist performs the following general tasks:

- Documents initial conditions.
- Verifies existing system operation and calibration (pre-removal).
- Replaces the nephelometer, datalogging and control subsystem, and AT/RH sensor.
- Verifies replacement system operation and calibration.
- Trains site operator(s).

In addition, nephelometers are typically audited at least once a year, but can be audited at anytime. The audits are performed by independent auditors.

SOP 4115, *Annual Site Visits for Optical Monitoring Instrumentation (IMPROVE Protocol)*, describes the annual site visit. Detailed procedures for the annual site visit are provided in TI 4115-3005, *Annual Site Visit Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)* and SOP 4700, *Optec NGN-2 Nephelometer Audit Procedures (IMPROVE Protocol)*.

4.5 ANNUAL LABORATORY MAINTENANCE

The Optec NGN-2 nephelometer is a precision instrument that requires careful cleaning and inspection to ensure optimum measurement accuracy. This level of servicing must be performed in a laboratory environment using specialized electronic and optical test equipment. Nephelometers operating in the IMPROVE network are replaced in the field and serviced on an annual basis.

When the operational instrument is removed from the field, it is shipped back to ARS for servicing. Each instrument must be fully serviced before it is reinstalled at a field site. Servicing includes the following major tasks:

- Visual inspection
- Post-field calibration
- Cleaning
- Hardware upgrade/modifications
- Component functional tests
- Pre-field calibration

Specific tasks in the laboratory servicing procedure are shown in Figure 4-2, Annual Service Procedure for Optec NGN-2 Nephelometers. Each servicing task and procedure for performing the task is fully described in TI 4100-3400, *Nephelometer Annual Laboratory Maintenance (IMPROVE Protocol)*.

Instrument calibration is described in SOP 4200, *Calibration of Optical Monitoring Systems (IMPROVE Protocol)*. Calibration procedures are presented in TI 4200-2000, *Calibration of Optec NGN-2 Nephelometers (IMPROVE Protocol)*.

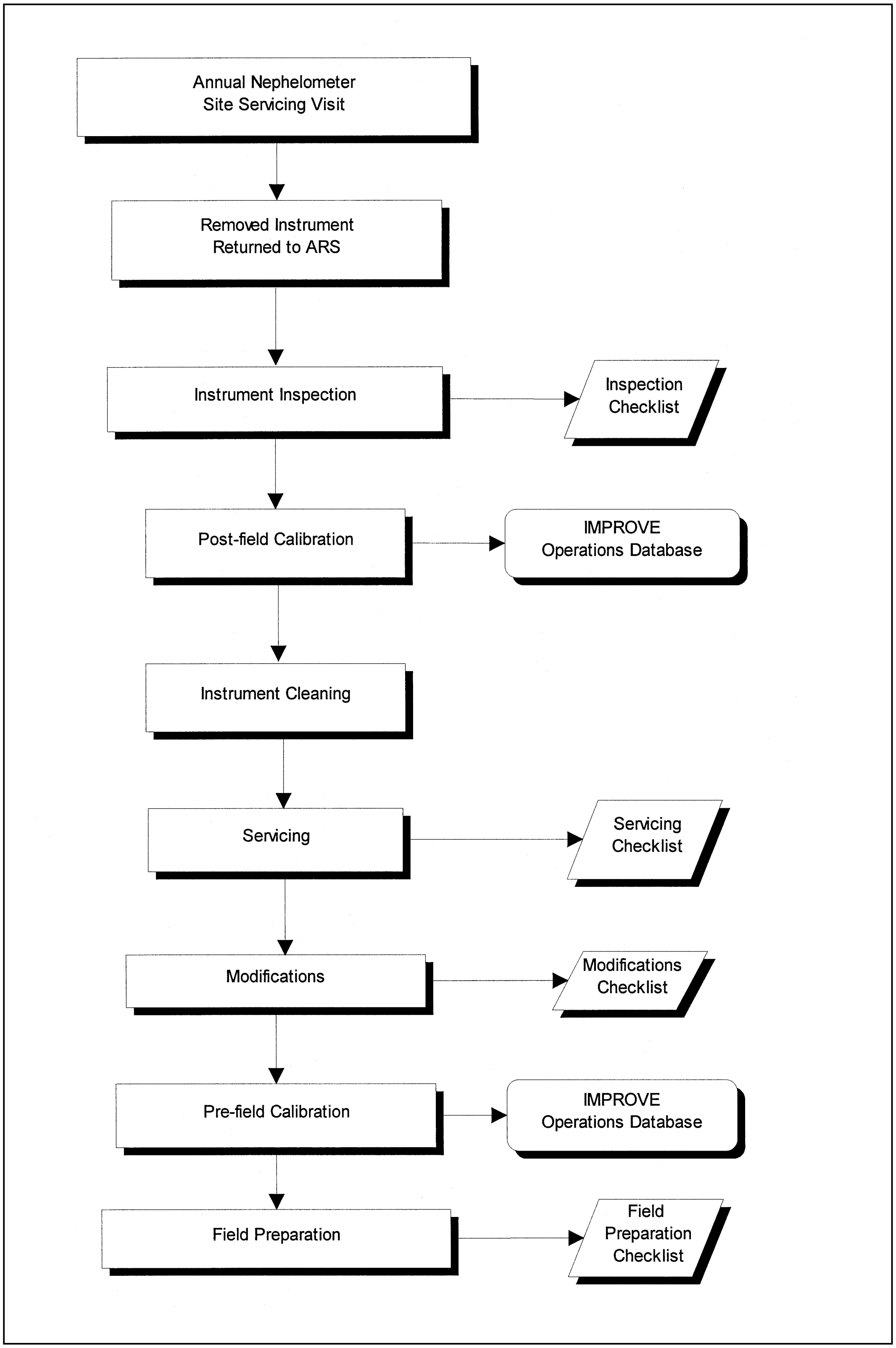

Figure 4-2. Annual Service Procedure for Optec NGN-2 Nephelometers.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**ROUTINE SITE OPERATOR MAINTENANCE PROCEDURES FOR OPTEC NGN-2 NEPHELOMETER SYSTEMS (IMPROVE PROTOCOL)**
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TITLE	NAME	SIGNATURE
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PROJECT MANAGER	James H. Wagner	
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QA MANAGER	Gloria S. Mercer	
OTHER		

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2.0	Revised upscale calibration procedures	April 1995	
2.1	Revised nephelometer/meteorology log sheet	July 1995	
3.0	Added troubleshooting procedures	October 1995	
4.0	Added responsibilities and format change	October 1996	

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the steps of a routine site operator maintenance visit to an Optec NGN-2 nephelometer station operated according to IMPROVE Protocol. The purpose of routine site operator maintenance is to assure quality data capture and minimize data loss by:

- Performing weekly operational checks and preventive maintenance on nephelometers, meteorological sensors, data acquisition and control systems, and support equipment.
- Initiating an upscale (span) and zero check at every visit.
- Inspecting the clean air filter prior to the calibration check and replacing if necessary.
- Changing the Campbell storage module at two-week intervals at sites where telephone modem data collection is not possible.
- On-site troubleshooting of the NGN-2 nephelometer system.

The nephelometer servicing schedule is provided in Table 1-1.

This TI, as referenced from Standard Operating Procedure (SOP) 4100, *Nephelometer Maintenance (IMPROVE Protocol)*, specifically describes the service and maintenance procedures to be performed at nephelometer stations. A summary of the procedures is provided in Table 1-2. Tasks are listed in the suggested order of completion. For more detailed instructions, see Section 4.0.

Due to variations in the site configurations of IMPROVE Protocol sites, portions of this TI may not apply to every station.

Table 1-1

Nephelometer Servicing Schedule

INTERVAL	TASKS
Weekly Interval	Check integrity of the tower and mounting hardware. Check integrity and operation of the support system. Check operation and calibration of the ambient nephelometer. Inspect the clean air filter. Check operation of the AT/RH sensor. Complete log sheet.
2 Week Interval	Exchange storage module at sites where telephone modem data collection is not possible.
Annual Interval	Field specialists will make visits once a year to exchange the existing nephelometer for a newly serviced instrument. Training of site operators in the servicing and maintenance of the monitoring system components will take place during annual field specialist visits.

Table 1-2

Nephelometer Station
Summary of Servicing Tasks

ORDER OF COMPLETION	SERVICING TASKS
Before leaving the office	Set your digital watch to the correct time prior to leaving the office by calling the National Bureau of Standards (NBS) recording at 303/499-7111 (Boulder, CO). Gather all required equipment and materials (Section 3.0).
Complete servicing tasks	Complete the general information section on the NGN-2 Nephelometer/Meteorology Log Sheet. Inspect and document the condition of the support tower, guy wires, and/or other structural components. Verify that AC and DC power is on by inspecting the indicator lamps on the support system front panel. Replace the AC and/or DC fuse(s) if necessary. Document the condition of the support system and that the connectors and cables are secure and in good condition. Record the value displayed on the support system front panel LCD. Document nephelometer operational problems indicated on the support system front panel display and perform any corrective action. Record the 21X datalogger current AT/RH, nephelometer, and other readings by scrolling through the intermediate storage locations. Check the year and Julian date on the 21X datalogger; change if necessary. Check the time on the 21X datalogger. Reset the time if it differs from the NBS by more than one minute. Return the 21X datalogger to the "RUN" mode after checking or setting the time. Document the condition of the inlet screen and door gasket. Document the condition and operation of the nephelometer, fan, and clean air pump. Observe and document the status of the nephelometer door and lamp. Inspect the clean air filter and replace if necessary. Check the light trap for contamination and clean as required. Document the last span and zero calibration check by recording the values stored in the appropriate 21X datalogger intermediate storage locations as displayed on the datalogger. Initiate a span and zero calibration check.

Table 1-2 (Continued)

Nephelometer Station
Summary of Servicing Tasks

ORDER OF COMPLETION	SERVICING TASKS
Complete servicing tasks	Observe the nephelometer Power-On Self Test (POST). Document any nephelometer functions that fail to occur. Document the results of the span and zero calibration check by recording the values stored in the appropriate 21X datalogger intermediate storage locations as displayed on the datalogger. Document the condition of the AT/RH sensor. Document the condition and/or operation of the wind sensors if they are present. Document the condition and/or operation of the AT/RH screen and aspiration fan. At sites where telephone modem data collection is not possible, exchange the Campbell storage module with a replacement module. Record the location, serial number, operator, and the date and time the module was removed along with the last data recorded on the module (*7 mode on the 21X) on the Storage Module Quality Assurance Card and on the NGN-2 Nephelometer/Meteorology Log Sheet. Record the location, serial number, operator, and the date and time the replacement module was installed on its Storage Module Quality Assurance Card. Complete the NGN-2 Nephelometer/Meteorology Log Sheet and note any inconsistencies. Leave the yellow copy of the log sheet in the site operator's manual and bring the white original back to the office.
Back at the office	Immediately fax a copy of the white original NGN-2 Nephelometer/Meteorology Log Sheet to ARS. Mail the white original log sheet along with any other documentation to ARS. Ship the exchanged storage module to ARS along with its Storage Module Quality Assurance Card. Call an ARS field specialist or data coordinator promptly if a problem or need arises.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Coordinate with the site operator, his/her supervisor, field specialist, and data coordinator concerning the schedule and requirements for routine maintenance.
- Oversee and review documentation completed by the site operator for accuracy and completeness.

2.2 FIELD SPECIALIST

The field specialist shall:

- Coordinate with the site operator, his/her supervisor, project manager, and data coordinator concerning the schedule and requirements for routine maintenance.
- Train the site operator in all phases of the routine maintenance and special servicing procedures necessary for site visits.
- Provide technical support to the site operator via telephone to assure high quality site visits.
- Document all technical support provided to the site operator.
- Resolve problems reported by the site operator.

2.3 DATA COORDINATOR

The data coordinator shall:

- Coordinate with the site operator, his/her supervisor, project manager, and field specialist concerning the schedule and requirements for routine maintenance.
- Review documentation completed by the site operator for accuracy and completeness.
- Verify that scheduled visits are performed and notify the site operator if he/she fails to make a scheduled visit.
- Provide technical support to the site operator via telephone to assure high quality site visits.
- Document all technical support provided to the site operator.
- Review and file all site documentation.
- Resolve problems reported by the site operator.

- Ship cleaning and other necessary supplies for routine maintenance to the site operator.
- Enter all correspondence with site operators and the results of all performed procedures into site-specific timelines.

2.4 SITE OPERATOR

The site operator shall:

- Coordinate with his/her supervisor, project manager, field specialist, and data coordinator concerning the schedule and requirements for routine maintenance.
- Perform all procedures described in this TI.
- Thoroughly document all procedures on the NGN-2 Nephelometer/Meteorology Log Sheet and fax and mail the log sheet to the data coordinator.
- Report any noted inconsistencies immediately to the data coordinator or field specialist.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The equipment generally required to support a weekly site visit includes:

- Medium flat-blade screwdriver
- Medium adjustable wrench
- Keys for the support system internal lock and padlocks
- Site Operator's Manual for Nephelometer Systems
- NGN-2 Nephelometer/Meteorology Log Sheet
- Pen or pencil
- Julian date calendar
- Nephelometer lamp
- Nephelometer clean air filter cartridge
- 2-amp and 7-amp AGC glass fuses
- Digital watch
- Kimwipes
- Replacement Campbell storage module (if telephone modem data collection is not possible)

4.0 METHODS

This section includes four (4) major subsections:

4.1 Routine Servicing
4.2 On-Site Troubleshooting
4.3 Problems or Questions
4.4 Handling Log Sheets

The procedures described in these sections refer to specific instrument components. Detailed schematic diagrams and instrument component descriptions are provided for reference in TI 4100-3350, *NGN-2 Nephelometer Monitoring System Diagrams and Component Descriptions*.

4.1 ROUTINE SERVICING

This subsection describes nephelometer monitoring routine servicing tasks and log sheet entries. Task descriptions are listed in the order in which they appear on the operator log sheet. Information or procedures to be followed are described with the appropriate log sheet entry (see Figure 4-1).

The nephelometer operator log sheets are divided into seven (7) main sections:

- Support Tower, Guy Wires and/or Other Structural Components
- AC and DC Power Indicator Lamps
- Datalogger
- Nephelometer
- Meteorology
- Support System
- General Comments and Supplies Needed

The following general information appears at the top of the nephelometer log sheet.

LOCATION	Enter either the full location name or the four-letter site abbreviation.
DATE	Use the standard calendar date, not the Julian date.
TIME	Current local time in 12-hour format should be used. Use Daylight Savings Time when applicable and indicate AM/PM and time zone (e.g., MST, PDT). Before leaving the office, set your digital watch to the correct time by calling the National Bureau of Standards recording 303/499-7111 (Boulder, CO).
OPERATOR(S)	Use your full name, or use your first initial and last name.

Air Resource Specialists, Inc.

Location ___________________

NGN-2 NEPHELOMETER/METEOROLOGY LOG SHEET

Date ____________________ Local Time _______:_______ (   ) Operator(s) ________________________________

Weather Conditions (Temperature, Wind, Precipitation) ________________________________

Visibility Conditions ________________________________

Support Tower, Guy Wires and/or Other Structural Components

1. Physical condition:________________________________

AC and DC Power Indicator Lamps

1. Status of the red AC indicator lamp: **ON** **OFF** If off, replace AC fuse (2-amp) and note time _____:______:____
2. Status of the green DC indicator lamp: **ON** **OFF** If off, replace DC fuse (7-amp) and note time _____:______:____

Datalogger

1. General Physical Condition: ________________________________
2. The support system front panel display will show a NEGATIVE number to indicate certain nephelometer operating problems. If the display is approximately one of the following values, perform the action listed and note the time.

Display	Problem	Action	Time (HH : MM)
-400	Lamp burned out	Replace nephelometer lamp, then push red reset button on the support front panel for 5 seconds	______:______
-500	Rain event	None required	______:______
-600	Bad chopper motor frequency	Push red reset button on support system front panel	______:______
-900	Serial data interface failure	Call ARS	______:______

3. Record the following parameters from the datalogger:

Key Sequence	Display	Measurement Parameter	
*64A	04: _________	Nephelometer status code: 1 = good read (ambient), 2 = clean air (zero calibration), 3 = span calibration, 4 = lamp out, 5 = rain, 6 = chopper	
A	05: _________	Nephelometer ambient reading (Reading must be > than last zero (*612A))	
*68A	08: _________	Nephelometer power supply (VDC)	**Call ARS if power is less than**
A	09: _________	Campbell 21X internal battery voltage (VDC)	**12 volts or greater than 15 volts**.
*611A	11: _________	b_{scat} (km^{-1}) or problem code. Does this match front panel display? (Call ARS if it does not)	
*617A	17: _________	Nephelometer lamp intensity (counts)	**Call ARS if counts are below 1500**

4. Check the datalogger date and time: **Note: The 21X datalogger is always kept on Standard Time.**
   a. Synchronize your watch with NBS (WWV) time. (303-499-7111)
   b. Record time on your watch (HH:MM:SS) _____:_____:_____
   c. Record datalogger date and time:

Key Sequence	Current Display	
*5	_____:______:_____	Current time (HH:MM:SS)
A	05:_______________	Year
A	05:_______________	Julian date

   d. IF DATE IS INCORRECT OR TIME DIFFERS BY MORE THAN 1 MINUTE FROM NBS TIME, CALL ARS
   e. Return datalogger to run mode:

Key Sequence	Display
*0	LOG12

Nephelometer

1. General physical condition :________________________________
2. Condition of the inlet screen and door gasket: ________________________________
   (If the screen or gasket is obstructed, call ARS for instructions)
3. Sample fan: **ON** **OFF** Condition of the sample fan and fan guard: ____________________
4. Clean air pump: **ON** **OFF**
5. Nephelometer door: **OPEN** **CLOSED**
6. Lamp cycling at the 2-minute ON, 3-minute OFF schedule? **YES** **NO**
7. Inspect clean air filter: **YES** **NO** Replaced **YES** **NO** Condition of old clean air filter: ________________
8. Remove and inspect light trap: **YES** **NO** Condition of light trap: ____________________

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Figure 4-1. NGN-2 Nephelometer/Meteorology Log Sheet.

9. Calibration - Before beginning calibration, check the *612 and *613 positions on the 21X datalogger (see #11 below).
   *612A Display ___________ *613A Display ___________
   a. Turn flowmeter off (clockwise rotation).
   b. Connect the calibration gas hose to the regulator outlet.
   c. Turn on the span gas tank valve (1/2 turn).
   d. Press and hold the red reset button on the support system front panel for 5 seconds.
   Record the time the red reset button was pressed: _____:_____:_____
   e. The nephelometer will initiate a Power-On Self Test (POST). Document that the POST functions operate correctly:

• Door close and open:	**YES**	**NO**
• Lamp and chopper on:	**YES**	**NO**
• Fan on and off:	**YES**	**NO**
• Solenoid on and off:	**YES**	**NO**
• Clean air pump on and off:	**YES**	**NO**
• Valve on and off:	**YES**	**NO**
• Fan on; solenoid turns on:	**YES**	**NO**
• One-minute ambient reading:	**YES**	**NO**
• Door closes:	**YES**	**NO**

   f. Adjust the span gas regulator pressure control valve to 2-4 psi. Record the pressure: ______________________________
   g. **Slowly** adjust the flowmeter to approximately 20 mm on the Cole Parmer flowmeter. (Make sure the door has been closed for at least 30 seconds before adjusting the flowmeter). Record the flow value: __________ mm
   h. Following the POST, the system will perform a 20-minute span calibration check, followed by a 1-minute span gas purge, followed by a 15-minute clean air zero calibration check.
   i. When the nephelometer door opens (36 minutes after starting the span calibration check) the span and zero calibration checks are complete.

10. TURN THE SPAN GAS TANK VALVE FULLY OFF. Disconnect the calibration gas hose at the regulator outlet to bleed excess gas from the hose, and turn the flowmeter off (clockwise rotation).
11. Record the results of the zero and span calibration checks from the datalogger:

Key Sequence	Display	Measurement Parameter
*612A	12: _________	Last zero calibration check (counts)
A	**13: _________	Last span calibration check (counts) **This number should be slightly different than the *613A reading taken before the calibration check.

Meteorology (Air Temperature/Relative Humidity Sensor; Wind Speed and Wind Direction Sensors)
1. General physical condition:____
2. Wind sensors unobstructed and free moving: **YES** **NO** Comment if NO:______________________________
3. AT/RH aspiration fan operating: **YES** **NO** Condition of the AT/RH screen: ____________________
4. Record the following meteorological parameters from the datalogger: **(Note - not all sites have wind speed and wind direction sensors)**

Key Sequence	Display	Measurement Parameter
*61A	01: _________	Ambient temperature (C)
A	02: _________	Ambient relative humidity (%)
*652A	52: _________	Wind speed (mph)
A	53: _________	Wind direction (degrees true)

5. Datalogger values reasonable for current conditions: **YES** **NO** Comment:________________________________

Support System
1. If required, exchange the Campbell SM716 or SM192 storage module with a new one. Record the following:

	Old module	New module
Model (SM192, SM716)	__________	__________
Serial number	__________	__________
Time removed/installed (HH:MM)	_____:_____	_____:_____

2. Complete removal information on the old module's Quality Assurance Card and installation information on the new card.
3. Check all connectors.
4. Call ARS immediately if you have any problems or questions.

General Comments and Supplies Needed

____
____
____
____

FAX and mail the original white 2-page log sheet to:
Leave yellow copy on-site

Air Resource Specialists, Inc.
Attn: Data Coordinator
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
Fax: 970-484-3423

ngnlog5.sam (6/96)

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Figure 4-1. (Continued). NGN-2 Nephelometer/Meteorology Log Sheet.

WEATHER CONDITIONS

Describe current or recent weather conditions that may be helpful in interpreting the nephelometer readings. Such conditions may include, but are not limited to:

- Passing storm fronts
- Impending precipitation
- Precipitation events
- Stagnant air masses
- High winds
- Fog

VISIBILITY CONDITIONS

Describe current or recent visibility conditions that may be useful in verifying correct nephelometer operation. A partial list of such conditions includes:

- Extremely clean
- Regional haze
- Layered haze
- Plumes visible
- Severity of haze
- Emission source activity (e.g., nearby forest fires, controlled burns, construction, dusty roads, residential wood burning, etc.)
- Any perceptible odors (e.g., wood smoke)

4.1.1 Support Tower, Guy Wires, and/or Other Structural Components

PHYSICAL CONDITION

Check the integrity of the tower and mounting hardware including tower stability, guy wire tension, tightness of mounting bolts and nuts, and aesthetic conditions. Document any problems and promptly telephone ARS.

4.1.2 AC and DC Power Indicator Lamps

RED AC INDICATOR LAMP

The red indicator lamp on the front panel of the support system indicates whether or not AC power is reaching the support system. If the lamp is not illuminated, check for the following:

- Power is turned off at the main breaker box.

- The support system is not plugged in.

- The AC fuse on the front panel is blown.

If the AC fuse is blown, replace it with a 2-amp, AGC, fast-blow glass fuse. Upon replacement of the fuse, the nephelometer should begin its Power-On Self Test and span/zero sequence. If the fuse blows again, do not replace it. Call ARS immediately whenever a fuse has blown.

GREEN DC INDICATOR LAMP

The green indicator lamp on the front panel of the support system indicates whether or not the main 13.8 volt DC power supply is operating. The DC power supply provides power to operate the nephelometer. The datalogger is powered by its own rechargeable internal battery. If the green indicator lamp is not illuminated, check for the following:

- The Red AC indicator lamp is not illuminated; AC power must be available to the DC power supply.
- The DC fuse on the front panel is blown.

If the DC fuse is blown, replace it with a 7-amp AGC fast-blow glass fuse. Upon replacement of the fuse, the nephelometer should begin its Power-On Self Test and span/zero sequence. If the fuse blows again, do not replace it. Call ARS immediately whenever a fuse has blown.

4.1.3 Datalogger

Datalogger condition and function should both be checked, as follows:

GENERAL PHYSICAL CONDITION

Describe any accumulation of dirt or other contamination, damage, or other physical problems regarding the support system or its mounting hardware.

SUPPORT SYSTEM DISPLAY

The support system front panel display usually indicates the ambient scattering value calculated from the last ambient nephelometer reading. However, if the nephelometer automatically suspends its operation due to a detected precipitation event or if the instrument fails, the display will indicate an error code (negative number) that may assist in troubleshooting the instrument. Record the displayed value on the log sheet.

Promptly call ARS if an error code is noted on the display.

Error Code -400: Nephelometer Lamp Burned Out
Replace the lamp as described below (refer to Figure 4-2):

BE CAREFUL, THE LAMP MAY BE HOT.

NEVER TOUCH THE LAMP GLOBE WITH BARE FINGERS; SKIN OILS MAY CAUSE THE LAMP TO FAIL OR BREAK.

- The nephelometer lamp is accessed via a rectangular bracket on the back of the nephelometer.
- Disconnect the gray cable going into the back of the bracket at the black, twist-off connector.
- Remove the two black knobs securing the nephelometer lamp bracket.

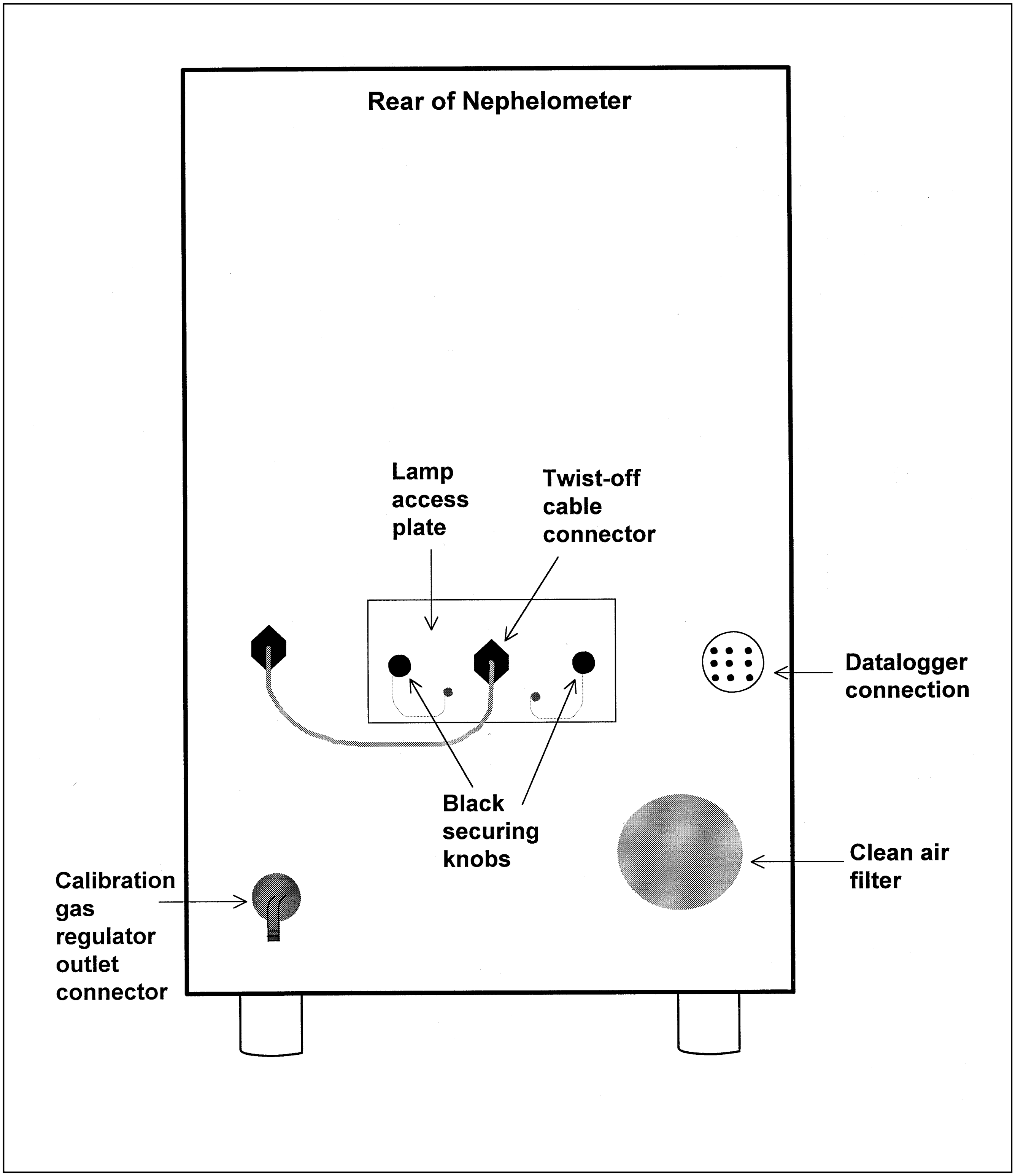

Figure 4-2. Nephelometer Lamp Replacement Diagram.

- Carefully slide the lamp bracket out of the nephelometer.

- Slide the lamp up and out of the bracket and disconnect it from the lamp socket.

- Insert the new lamp into the lamp socket and slide it into the lamp bracket. Be sure that the lamp is properly seated in the socket.

- Carefully slide the lamp bracket into the nephelometer.

- Reinstall the two black knobs.

- Reconnect the gray cable to the back end of the bracket.

Reset the nephelometer by pressing the red pushbutton on the support system front panel for five seconds (refer to Figure 4-3). The nephelometer will initiate its Power-On Self Test and span/zero sequence (see Section 4.1.4). Document the time the nephelometer was reset.

Error Code -500: Rain Event
The nephelometer sensed a precipitation event and has shut down until the precipitation sensor is dry. Ambient readings will automatically resume when the sensor is dry; no operator intervention is required.

Error Code -600: Bad Chopper Motor Frequency
The nephelometer was unable to keep the frequency of the chopper motor within tolerance.

Reset the nephelometer by pressing the red pushbutton on the support system front panel for five seconds (refer to Figure 4-3). The nephelometer will initiate its Power-On Self Test (POST) and span/zero sequence (see Section 4.1.4). If the nephelometer fails to initiate the POST, call ARS for instructions. Document the time the nephelometer was reset.

Error Code -900: Serial Data Interface Failure
The 21X datalogger was unable to capture the serial data stream from the nephelometer. The most likely cause is a failure of the serial interface subsystem in the support system. Call ARS for instructions.

CABLES AND CONNECTORS

The support system cables connect the support system to the nephelometer, AT/RH sensor, AC power, telephone line, DCP (if present), and computer interface (if present) through connectors on the bottom of the enclosure. Check the cables and connectors. Verify that all cables are secure and check the integrity of the cables. Document any problems, including broken connectors, loose or bare wires, etc. Report any problems promptly to ARS.

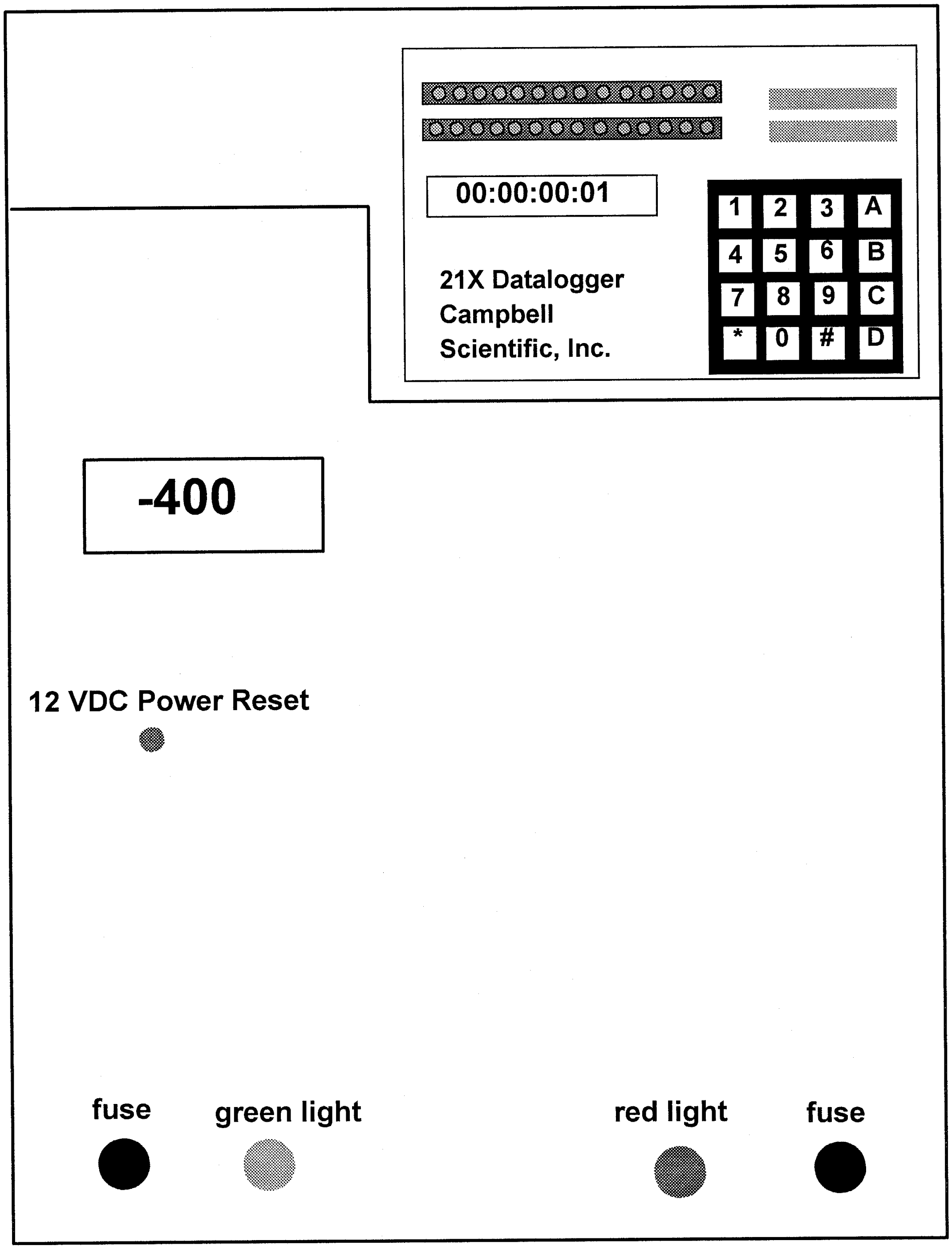

Figure 4-3. Datalogger Support System Front Panel.

CAMPBELL DATALOGGER FUNCTIONS

The Campbell 21X datalogger samples and stores the following data:

- Nephelometer serial outputs
- Rotronics AT/RH sensor outputs
- DC power supply voltage
- Date and time

The 21X also performs the following functions:

- Provides power to the nephelometer interface board
- Calculates ambient b_{scat} from nephelometer raw readings
- Drives the support system front panel display
- Stores data in the storage module
- Provides an analog output signal to the DCP (if present)
- Allows downloading of data via phone modem

DATALOGGER STORAGE LOCATIONS

Log the following current readings from the 21X datalogger intermediate storage locations by entering ***6** on the 21X keyboard to access the locations, and entering **A** to advance through the locations.

Key Sequence	Display	Measurement Parameter
*64A	04:_____	Nephelometer status code: 1=good read mbient), 2=clean air (zero calibration), 3=span calibration, 4=lamp out, 5=rain, 6=chopper
A	05:_____	Nephelometer ambient reading (Reading must be greater than last zero (*612A))
*68A	08:_____	Nephelometer power supply (VDC)
A	09:_____	Campbell 21X internal battery voltage (VDC)
*611A	11:_____	b_{scat} (km^{-1}) or problem code. Does this match the front panel display?
*617A	17:_____	Nephelometer lamp intensity (counts)

VERIFY OPERATOR WATCH SET TO NBS TIME

The 21X datalogger time should be set to **local standard time** synchronized to NBS time. The operator should set his/her watch to NBS local standard time by calling 303/499-7111. Indicate on the log sheet if time is synchronized to NBS time.

CHECKING AND SETTING THE DATE AND TIME

The 21X datalogger keeps track of the date in Julian date and year format. The date and time functions are accessed by entering ***5** on the 21X keyboard and entering **A** to advance through the parameters.

<u>Checking the time</u>
Access the 21X time mode by entering ***5** on the 21X keyboard. Record both the 21X time and the NBS time on the log sheet.

The 21X datalogger time should only be set if it differs by more than one minute from NBS time.

<u>Setting the time</u>
Advance to the time set display by entering ***5AAA**. Enter the correct time at the top of a minute as HH:MM and press **A** to input the change. Record the time entered on the log sheet. Press ***5** to verify that the time change was entered properly and is now synchronized with NBS time.

<u>Checking and setting the year</u>
Advance to the year by entering **A** and record the year. If the year is incorrect, enter the correct year on the keyboard and press **A** to input the change. Record the year entered on the log sheet.

<u>Checking and setting the Julian date</u>
Advance to the Julian date by entering **A** and record the Julian date. If the Julian date is incorrect (refer to a Julian date calendar), enter the correct Julian date on the keyboard and press **A** to input the change. Record the Julian date entered on the log sheet.

PLACING IN RUN MODE — Enter ***0** on the 21X keyboard to place the 21X in the "RUN" mode. The 21X display will show "LOG12" to indicate correct correct operation. If the 21X does not display "LOG12," call ARS immediately for instructions.

4.1.4 <u>Nephelometer</u>

The condition and function of the nephelometer and its components should be checked as follows:

GENERAL PHYSICAL CONDITION — Describe any accumulation of dirt, contamination, damage, or other physical problems regarding the nephelometer or its mounting system.

INLET SCREEN AND DOOR GASKET — The nephelometer inlet screen keeps insects and large debris from entering the measurement chamber. The door gasket creates a tight seal when the door closes for span and clean air zero calibrations. Document the condition of the nephelometer inlet screen and door gasket. Note excess dirt, snow, ice, or foreign materials. Remove any obstructions from the screen and/or door gasket. If either the screen or the gasket are very dirty, damaged, or severely obstructed, call ARS for instructions.

SAMPLE FAN AND FAN GUARD

The nephelometer sample fan draws ambient air in through the inlet screen and exhausts it past the fan guard on the bottom of the instrument. Listen to the fan and feel for the air flow out of the fan. Document any problems (fan not running, noisy, clogged, etc.). Inspect the fan guard and brush off any insects or accumulated debris. Document the condition of the fan and fan guard.

CLEAN AIR (ZERO) PUMP

The nephelometer clean air pump recirculates air within the measurement chamber through a 0.3-micron filter to remove particles from the air. The clean air pump is on and the door is closed during automatic clean air zero calibrations and during power-up span/zero checks. The pump makes a low frequency hum distinct from the sound of the sample fan. Document whether the pump is on or off.

INITIAL DOOR POSITION

The position of the nephelometer door indicates whether the instrument is taking ambient readings, performing an automatic clean air calibration, or has failed. Ambient readings are taken when the door is open. The nephelometer performs a 15-minute automatic clean air calibration at pre-programmed intervals (e.g., every 6 or 30 hours). The door remains closed during this period. The nephelometer will also automatically go through a Power-On Self Test and 35-minute span/zero sequence every time power is interrupted and restored to the unit. The door also remains closed for a majority of the span/zero sequence. If the door is closed upon arrival at the site, WAIT for 15 minutes before determining whether the nephelometer has failed. If the nephelometer has failed, an error code may be displayed on the support system front panel display (see error code descriptions below). Document the position of the door.

LAMP STATUS

When the door is open and all components are operating properly, the nephelometer takes a two-minute reading with the lamp on, followed by a three-minute period with the lamp off. The door is open and the fan is on during the entire five-minute period. The lamp will appear to flash as the light is chopped by an internal motor. Verify that the lamp cycles according to the two-minute-on/three-minute-off schedule and that it is flashing. Document the operation of the lamp.

CLEAN AIR FILTER

Inspect the clean air filter cassette (refer to Figure 4-4):

- Remove (unscrew by hand) the entire filter assembly from the nephelometer.
- Remove (unscrew by hand) the retainer cap from the back of the assembly.
- Remove (unscrew by hand) the filter cassette and replace with a new cassette, if necessary.

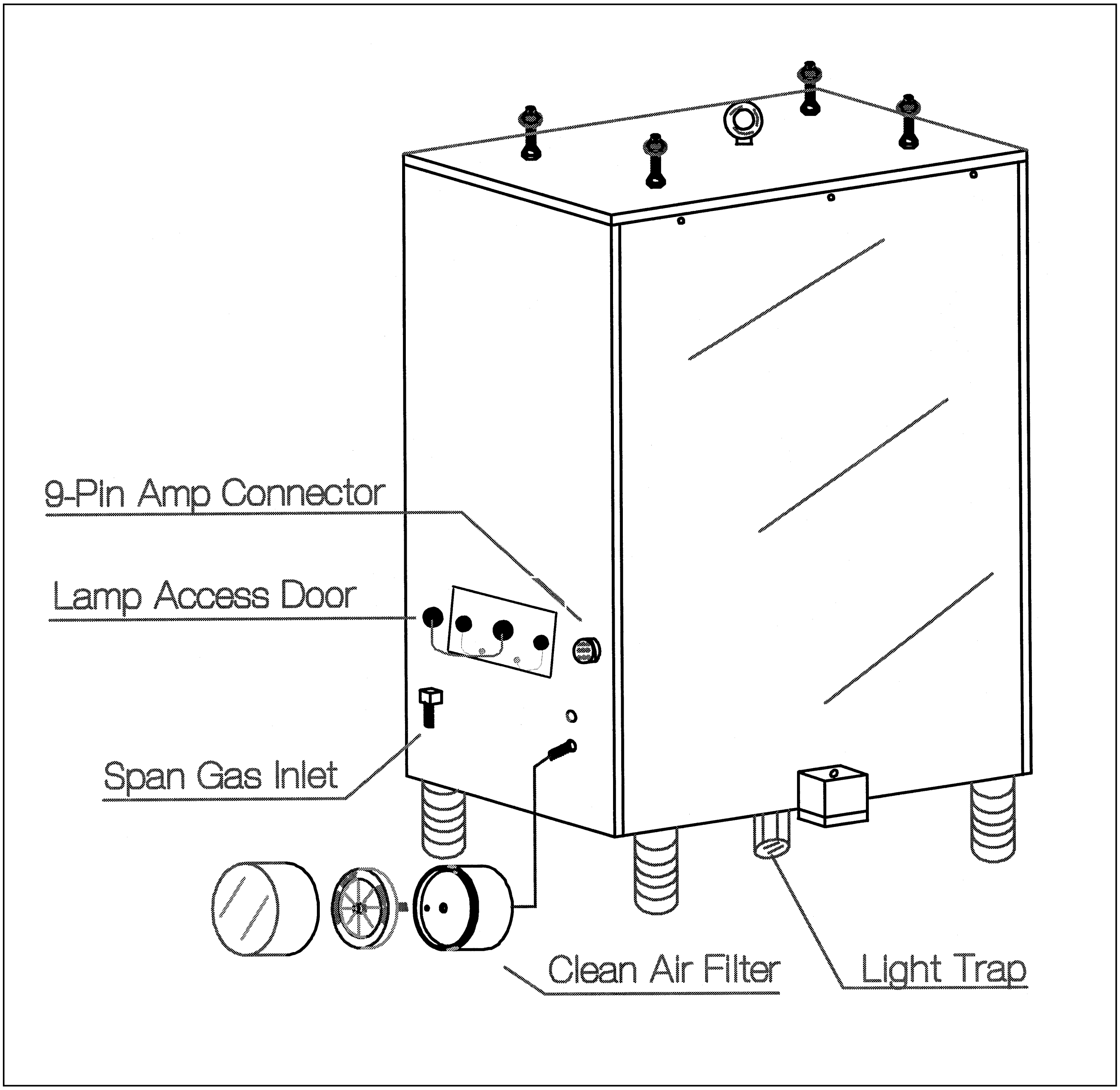

Figure 4-4. Diagram of the Clean Air Filter Assembly and Light Trap.

- Replace all parts in reverse order.

- Note the condition of the old filter (dirt, moisture, etc.).

LIGHT TRAP

Unthread (unscrew by hand) the light trap (refer to Figure 4-4). Note if any water or dirt is found inside the light trap. Clean with a Kimwipe or equivalent if necessary. Replace the light trap and hand tighten.

CALIBRATION PREPARATION

The nephelometer will perform a Power-On Self-Test (POST) followed by an automatic upscale and zero check when it is powered up or when the red pushbutton on the support system front panel is pressed. The upscale check is performed with SUVA 134a gas, which has a specific span value. Hence the check is commonly referred to as a span check. To prepare for the calibration sequence:

- Before starting the calibration, record the zero value from location "12" on the 21X datalogger by entering ***612A** on the datalogger keyboard. Advance to the upscale/span value in location "13" by entering **A**. Record the span value.

- Turn the flowmeter off by turning the black knob in a clockwise rotation.

- Connect the flowmeter input hose (bottom) to the calibration gas regulator outlet connector (see Figure 4-2).

- Turn on the calibration gas tank valve (1/2 turn).

- Reset the nephelometer by pressing and holding the red pushbutton on the front panel of the support system for five seconds. Record the 21X datalogger time (*5) the nephelometer was reset on the log sheet. The calibration sequence will begin.

Power-On Self Test (POST)

The POST sequence is as follows:

- Door closes

- Door opens

- Lamp turns on

- Fan turns on and off

- Internal solenoid turns on and off

- Clean air pump turns on and off

- Internal calibration gas valve turns on and off

- Fan turns on, solenoid turns on
- One-minute sample reading is taken
- Lamp turns off and door closes

Span and Zero Calibration

Following the POST, the span/zero sequence begins. The 20-minute span check occurs first, followed by a one-minute calibration gas purge, followed by a 15-minute clean air zero check. The span check requires that a source of calibration gas is available to the nephelometer during the calibration process. At the end of the 36 minutes, the span and zero values are available on the Campbell 21X datalogger. Carry out the following procedures to initiate a span and zero check:

- Observe the Power-On Self Test (POST). Document whether or not the POST was successful.
- At the beginning of the span gas calibration, adjust the regulator output pressure to 2 to 4 psi and record the pressure.
- Slowly open the flowmeter valve, increasing the flow to approximately 2 lpm (corrected). Use settings of approximately 20 mm when using the suggested Cole Parmer flowmeter. Make sure the door has been closed for at least 30 seconds before adjusting the flowmeter. Check the individual flowmeter calibration for the actual value. Record the flow value on the log sheet. Note that the flowmeter value could vary as much as ±5 mm throughout the calibration. This level of variation is acceptable.
- Wait 36 minutes for the span and zero to occur. The nephelometer door will open when the check is complete.
- Upon completion of the calibration, TURN THE SPAN GAS TANK VALVE COMPLETELY OFF. Disconnect the calibration gas hose at the regulator outlet to bleed excess gas from the hose.
- Record the zero value from location "12" on the 21X datalogger by entering ***612A** on the datalogger keyboard. Advance to the span value in location "13" by entering **A**. Record the span value.
- Enter ***0** on the datalogger keyboard to place the datalogger in the "RUN" mode. The display will show "LOG12" to indicate correct operation.

The nephelometer will begin operating in ambient "RUN" mode upon completion of the span and zero check.

4.1.5 Meteorology

The condition and functions of meteorological sensors, including air temperature, relative humidity, and wind sensors should be checked as follows:

GENERAL PHYSICAL CONDITION	Describe any accumulation of dirt or other contamination, damage, or other physical problems regarding the AT/RH sensor, housing, or its mounting system. Remove any accumulation of snow or ice from the housing.
WIND SENSORS	If available at sites, verify that wind sensors are unobstructed and that they are free-moving.
ASPIRATION FAN	The AT/RH sensor aspiration fan eliminates the effect of heating of the housing and assures that the AT/RH sensor is measuring ambient air. The fan must always be running. Document the status of the aspiration fan and call ARS promptly if the fan is not functioning.
HOUSING SCREEN	The AT/RH housing screen keeps insects and debris out of the housing and away from the sensor. Remove foreign matter from the screen and record the condition of the screen.
RECORD CURRENT CONDITIONS	Record the following current meteorological parameters from the 21X datalogger by entering ***6** on the 21X keyboard to access the parameters, and entering **A** to advance through the locations.

Key Sequence	Display	Measurement Parameter
*61A	01:_____	Ambient temperature (°C)
A	02:_____	Ambient relative humidity (%)
*652A	52:_____	Wind speed (mph)
A	53:_____	Wind direction (degrees true)

Comment and document if the datalogger recorded meteorological conditions appear similar with current conditions observed at the site.

4.1.6 Support System

The Campbell storage module is the backup data storage medium at sites with a telephone modem. The storage module must be exchanged only upon instruction from ARS. The module will be used to fill in gaps in the data collected via telephone modems.

The Campbell storage module is the primary data storage medium at sites without a telephone modem. At these sites the DCP provides near-real time monitoring of the nephelometer system. At sites without a telephone modem, the storage module must be exchanged twice a month on the first and third visit of each month, in conjunction with the operator initiated span/zero checks.

STORAGE MODULE REMOVAL	Record the following information on the old module's Storage Module Quality Assurance Card (an example card is provided as Figure 4-5):

DATA STORAGE MODULE
QUALITY ASSURANCE CARD

Location________________

Module SN______________

Init._________ by_______

Fill/__________________

Full/Replace by___________

Date on_________________

Time on __________(____)

Installed by______________

Date off________________

Time off__________(____)

Removed by______________

Comment_______________

PGM in #8______________

PGM in #8______________

Figure 4-5. Example Data Storage Module Quality Assurance Card.

- Location
- Storage module model number (SM192 or SM716)
- Storage module serial number
- Operator
- Date and time of removal

Also record the serial number and time of removal on the log sheet.

STORAGE MODULE INSTALLATION

Upon installation of a new storage module, record the following information on the new module's Storage Module Quality Assurance Card:

- Location
- Storage module model number (SM192 or SM716)
- Storage module serial number
- Operator
- Date and time of installation

Also record the serial number and time of installation on the log sheet.

CHECK CONNECTIONS

Verify that the new module is connected fully and properly. Call ARS if problems occur.

SEND MODULE TO ARS

Promptly ship the removed storage module to ARS in the supplied shipping container. A replacement module will be returned in time for the next exchange.

4.1.7 General Comments and Supplies Needed

Document any unusual finding or problem experienced while performing the instrument checks. Also state any additional supplies needed.

4.2 ON-SITE TROUBLESHOOTING

4.2.1 General Troubleshooting Information

Nephelometer troubleshooting is normally initiated by either the site operator (in response to a problem observed during routine site servicing) or by the data coordinator in the ARS Data Collection Center (in response to operational problems detected during daily review of nephelometer data). A good practice to follow when troubleshooting a problem in the field is to start with the simple checks and progress toward the more complicated.

The majority of nephelometer problems are due to:

- Moisture in the nephelometer light trap and/or clean air filter.
- Nephelometer lamp malfunction.
- Electrical power outages or surges.
- Lightning induced voltage spikes on the telephone line.

In most cases, site operators can diagnose and solve instrument problems in the field, reducing costly site visits and minimizing data loss. In a few cases, an instrument or component malfunction that cannot be corrected in the field will be diagnosed and the instrument will need to be removed and returned to ARS for repair.

TROUBLE-SHOOTING

The source of most nephelometer system problems can be identified in the field by checking items in the following categories:

- Obvious Sources:
  - Moisture is in the light trap and/or clean air filter.
  - The lamp is burned out or operates intermittently.
  - The nephelometer door is malfunctioning (the door remains closed or open continually).
  - A malfunction exists in the calibration gas flowmeter or pressure regulator.
  - The calibration gas tank is empty or the valve will not open.
  - Electrical power is unplugged or is not turned on.
  - The telephone line/blue ribbon cables are not connected properly to the datalogger, modem, telespike, or storage module.
- Power Supply:
  - A fuse is blown in the datalogging and control subsystem enclosure.
  - The power connectors are not making good contact.
- Connectors:
  - A connector is not plugged in, or is in the wrong input position.
  - A connector is not making good contact.

- Connector pins or sockets are damaged.

- Moisture is in the connector.

- The cable/connector is damaged, resulting in broken wire or electrical short.

BEFORE CALLING FOR ASSISTANCE

Before reporting problems or requesting assistance in diagnosing an instrument problem, please do the following:

- Before leaving the nephelometer, be sure to perform and document the results of all instrument and support system checks specified on the NGN-2 Nephelometer/Meteorology Log Sheet.

- Check problem areas listed above (Obvious Sources, Power Supply and Connectors).

- Follow procedures for troubleshooting the observed problem (see Section 4.2.2).

- Have documentation of your tests available.

- Have a site operator's manual available.

Please call promptly with suspected or observed instrument problems. If the person you need to speak with is not in, ask to be directed to another or leave a message, including your name, location, telephone number, and a brief description of the problem(s) or need(s).

4.2.2 Specific Troubleshooting Procedures

On-site symptoms of a malfunctioning nephelometer system that would be observed by the site operator during a routine site visit can be grouped into the following categories:

- Nephelometer will not operate - the system does not appear to be operating and will not respond to system reset.

- Nephelometer malfunctions during Power-On Self Test (POST) - after resetting the system, the system fails to complete all tests conducted during the POST.

- Nephelometer span/zero calibration check is invalid or suspect - calibration check data are inconsistent with previous calibration check data.

- System error code is displayed on support system front panel - the support system has detected and identified an operational error.

Tables 4-1 through 4-4 list specific instrument, component, or procedural problems that can produce the symptoms described above. For each problem listed, the appropriate corrective action is described and reference is made to the section of this TI that provides detailed information for performing the specified corrective action.

Table 4-1

Troubleshooting Procedures
(Nephelometer Will Not Operate)

NEPHELOMETER WILL NOT OPERATE		
Symptom	Problem	Corrective Action
The DC power indicator light (green) on the support system front panel is "OFF."	Blown fuse	Replace fuse - 7 amp AGC (refer to Section 4.1.2, AC and DC Power).
The AC power indicator light (red) on the support system front panel is "OFF."	Blown fuse	Replace fuse - 2 amp, AGC (refer to Section 4.1.2, AC and DC Power).
	No AC power to support system	Check AC power connection.
The Uninterruptible Power Supply (UPS) "line on" and "backup on" indicator lights are "OFF."	No AC power to UPS	Check AC power connection for UPS power cable.

Table 4-2

Troubleshooting Procedures
(Nephelometer Malfunction During Power-On Self Test (POST))

NEPHELOMETER MALFUNCTION DURING POWER-ON SELF TEST (POST)		
Symptom	Problem	Corrective Action
The nephelometer door does not close completely.	Door obstructed	Inspect the door gasket and remove any obstructions (refer to Section 4.1.4, Nephelometer).
	Reset button malfunction	Disconnect the nephelometer DC power cable at the support system. Wait 5 seconds and reconnect. Document results and call ARS.
	Door motor or door motor control system malfunction	Call ARS.
The nephelometer door does not open properly.	Lamp out	Check and document the error code on the support system display. If the code is "-400," replace the lamp (refer to Section 4.1.3, Datalogger). If the door still will not open, call ARS.

Table 4-3

Troubleshooting Procedures
(Invalid or Suspect Calibration Check)

INVALID OR SUSPECT CALIBRATION CHECK		
Symptom	Problem	Corrective Action
Invalid or suspect clean air calibration.	Dirt or moisture in light trap	Clean the light trap (refer to Section 4.1.4, Nephelometer).
	Moisture in clean air filter	Replace the clean air filter (refer to Section 4.1.4, Nephelometer).
	Clean air pump malfunction	Verify that the clean air pump is operating (refer to Section 4.1.4, Nephelometer). If the pump is not operating, call ARS.
	Air leak around nephelometer door	Clean and remove any obstructions from the door gasket (refer to Section 4.1.4, Nephelometer).
	Air leak around clean air filter housing unit	Replace the clean air filter (refer to Section 4.1.4, Nephelometer).
	Dirty chamber	Check for pollen, bugs, spiders. Document finding and call ARS.
Low span (upscale) calibration check.	Adequate supply of calibration gas not getting into nephelometer chamber	Check control settings and connections, span gas tank valve, pressure regulator, hoses, and flowmeter (refer to Section 4.1.4, Nephelometer).
	Empty span gas tank	Check the tank and call ARS if it is low or empty.
	Air leak around nephelometer door	Clean and remove any obstructions from the door gasket (refer to Section 4.1.4, Nephelometer).
	Clean air pump malfunction	Verify that the clean air pump is operating (refer to Section 4.1.4, Nephelometer). If the pump is not operating, call ARS.
High span (upscale) calibration check.	Span gas flow too high	Check the flowmeter adjustment (refer to Section 4.1.4, Nephelometer).
	Condensation in chamber due to gas flow starting too quickly	Repeat the span/zero calibration check. Be especially careful to open the flowmeter valve **slowly**.
	Dirt or moisture in light trap	Clean the light trap (refer to Section 4.1.4, Nephelometer).
	Moisture in clean air filter	Replace the clean air filter (refer to Section 4.1.4, Nephelometer).

Table 4-4

Troubleshooting Procedures
(Error Code Displayed on Support System Front Panel)

ERROR CODE DISPLAYED ON SUPPORT SYSTEM FRONT PANEL		
Symptom	Problem	Corrective Action
Error Code -400	Lamp out	Replace lamp (refer to Section 4.1.3, Datalogger).
Error Code -500	Rain event	No operator intervention is required. Readings will resume when the sensor is dry.
Error Code -600	Incorrect chopper frequency	Reset the system by pressing the red reset button on the support system front panel (refer to Section 4.1.3, Datalogger).
Error Code -900	Serial data interface failure	Follow the procedures described in Section 4.1.3, Datalogger.

4.3 PROBLEMS OR QUESTIONS

Call ARS immediately if any problems occur or if any questions arise. Many problems can be resolved through telephone consultation.

ARS may be reached at the following telephone numbers:

Regular: 970/484-7941
Fax: 970/484-3423

4.4 HANDLING LOG SHEETS

The site operator must complete a nephelometer operator log sheet for each site visit. Upon returning to the office, fax the completed two-page log sheets to ARS (Fax 970/484-3423).

Also mail the original log sheets to ARS:

Air Resource Specialists, Inc.
Attn: Data Coordinator
1901 Sharp Point Drive Suite E
Fort Collins, CO 80525

Any additional information or other pertinent supplemental documentation that the operator deems important can also be included with the log sheets.

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the individual components of an IMPROVE NGN-2 nephelometer station, including:

- An Optec NGN-2 nephelometer.
- A gas calibration system.
- A data logging and control subsystem.
- A shielded and aspirated Rotronics ambient temperature and relative humidity sensor.
- A support tower and related hardware.
- A precipitation and solar radiation shield.

The descriptions in this TI may be used to build and/or troubleshoot the nephelometer system. Components in the system may change depending on site logistics, component availability, and construction. This technical instruction includes the following information:

- A brief description of component function
- Component model, manufacturer, and supplier
- System component diagrams
- Cable and connector descriptions
- Wiring diagrams and tables

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall ensure that the component descriptions in this TI are accurate, complete, and up-to-date.

3.0 REQUIRED EQUIPMENT AND MATERIALS

None.

4.0 METHODS

This section describes the system components and wiring of a nephelometer station and includes six (6) major subsections:

4.1 Optec NGN-2 Nephelometer
4.2 Gas Calibration System
4.3 Data Logging and Control Subsystem
4.4 Shielded and Aspirated Rotronics Ambient Temperature and Relative Humidity Sensor
4.5 Support Tower and Related Hardware
4.6 Precipitation and Solar Radiation Shield

4.1 OPTEC NGN-2 NEPHELOMETER

This section provides a brief overview of the Optec NGN-2 nephelometer. Detailed component descriptions for the nephelometer are provided in *Model NGN-2 Open-Air Integrating Nephelometer Technical Manual for Theory of Operation and Operating Procedures* (Optec, 1993). The NGN-2 uses a unique design that allows accurate measurement of the scattering component of ambient air. Extinction due to scatter can accurately be measured from Rayleigh to 100% saturated fog conditions.

4.1.1 Nephelometer Configuration

The nephelometer configuration is determined by the version of EPROM installed and user-selectable parameters stored in battery-backed RAM in the instrument. The following configuration is used for IMPROVE installations:

- EPROM Version 1057
- Clean air calibration intervals of 6 hours
- Operational mode #3 (2-minute integration every 5 minutes)
- Automatic span calibration upon power-up
- Automatic test upon power-up
- Default baud rate of 1200 bps
- Serial sign-on message (POST) enabled

4.1.2 Nephelometer Exterior and Cross-Sectional View Diagrams

Figure 4-1 presents the major exterior components of the nephelometer. Figure 4-2 is a cross-sectional diagram of the nephelometer as it appears in the Optec manual. Table 4-1 details the pin-out allocation for the 9-pin nephelometer connector.

4.2 GAS CALIBRATION SYSTEM

The gas calibration system is used to perform scheduled span and zero calibration checks of the nephelometer. These checks help ensure the nephelometer data are accurate. The system, illustrated in Figure 4-3, includes the following components:

- Span gas enclosure
- Span gas regulator
- Span gas rotameter with enclosure
- Span gas hoses
- Suva 134-a span gas tank

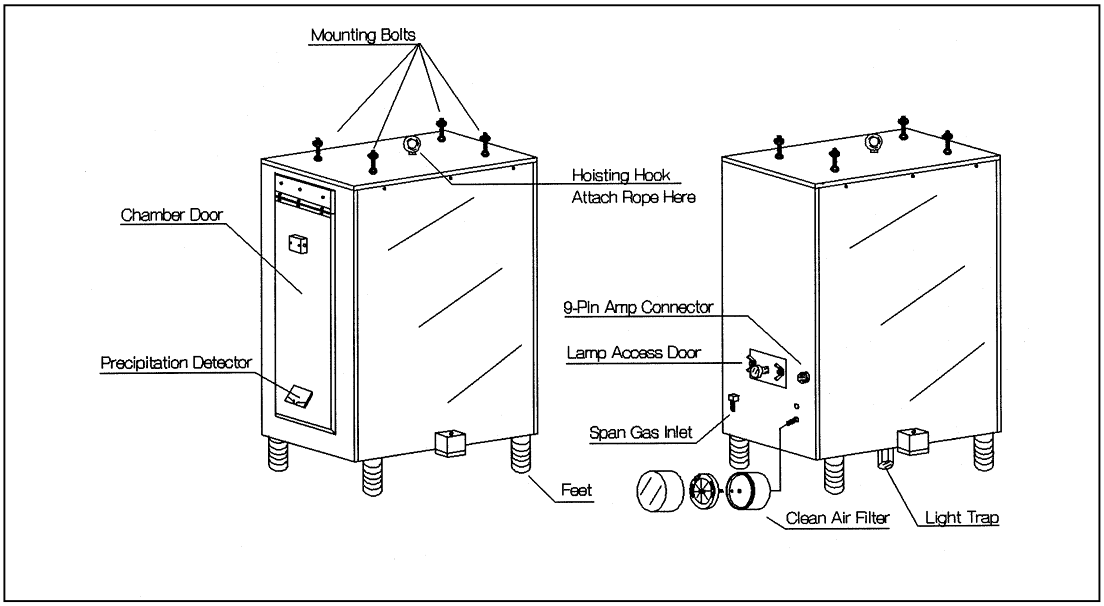


Figure 4-1. Optec NGN-2 Nephelometer Exterior Diagram.

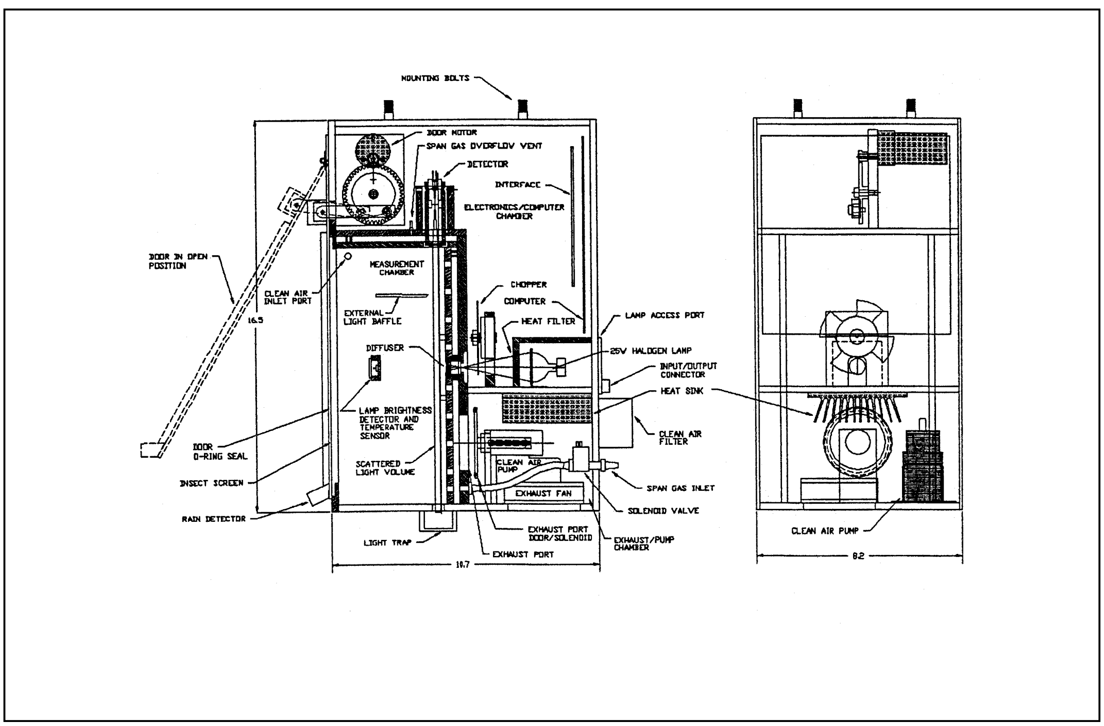


Figure 4-2. Optec NGN-2 Nephelometer Cross-Sectional View.

Table 4-1

Nephelometer 9-Pin Connector Description

NGN-2 Nephelometer Connector	
Pin #	Function
1	NEPH Power (13.8 VDC)
2	NEPH Power Return
3	Serial I/O, RS-232, RX
4	Serial I/O, RS-232, GND
5	Serial I/O, RS-232, TX
6	Ana1og-1 (scatter)
7	Analog-1 (common)
8	Analog-2 (status)
9	Analog-2 (common)

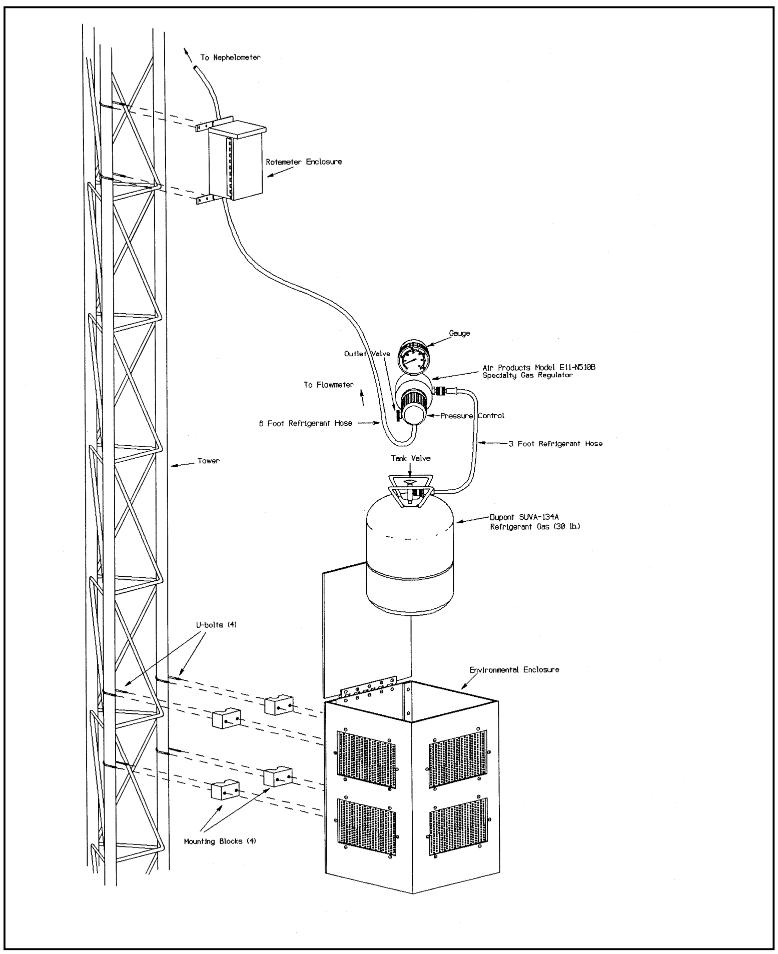


Figure 4-3. Span Gas Calibration System.

4.3 DATA LOGGING AND CONTROL SUBSYSTEM

The data logging and control subsystem supplies power to the nephelometer and allows for remote data collection. This section describes connectors, internal wiring, and sub-components in the data logging and control subsystem and contains the following subsections:

4.3.1 Major Sub-Components

Table 4-2 presents the category, manufacturer, supplier, and model number of the major components in the data logging and control subsystem. Figure 4-4 shows the placement of the components within the enclosure.

Table 4-2

Major Components of the Data Logging and Control Subsystem

Data Logging and Control Subsystem Components			
Category	Manufacturer	Supplier	Model
Datalogger	Campbell Scientific	Campbell Scientific	21XL
Storage Module	Campbell Scientific	Campbell Scientific	SM192 or SM716
Primary Modem	Campbell Scientific	Campbell Scientific	DC110
Auxiliary Modem	Black Box	Black Box	Tote-A-Modem 1200 or Tote-A-Fax
13.8 VDC, 10 amp Power Supply for Nephelometer	SOLA	Newark	86-13-310
AC Line Monitor	Campbell Scientific	Campbell Scientific	ACL1
Surge Protector	Stabiline	Newark	PQI-1115
Interface Circuit Board with Blue Earth Micro-controller	ARS and Blue Earth Research	ARS and Blue Earth Research	2.1
Fan Thermostat	Therm-O-Disk	W.W. Grainger	4E116
12 VDC, 49 CFM Fan	Pabst	Newark	3412
LDC Front Panel Display	Jewel	Digikey	5900102141
AMP Connectors	AMP	Digikey	9-pin and 4-pin
Telephone Line Surge Protector	TrippLite	Digikey	TeleSpike Blok TSB
External UPS System	TrippLite	Digikey	BC-250

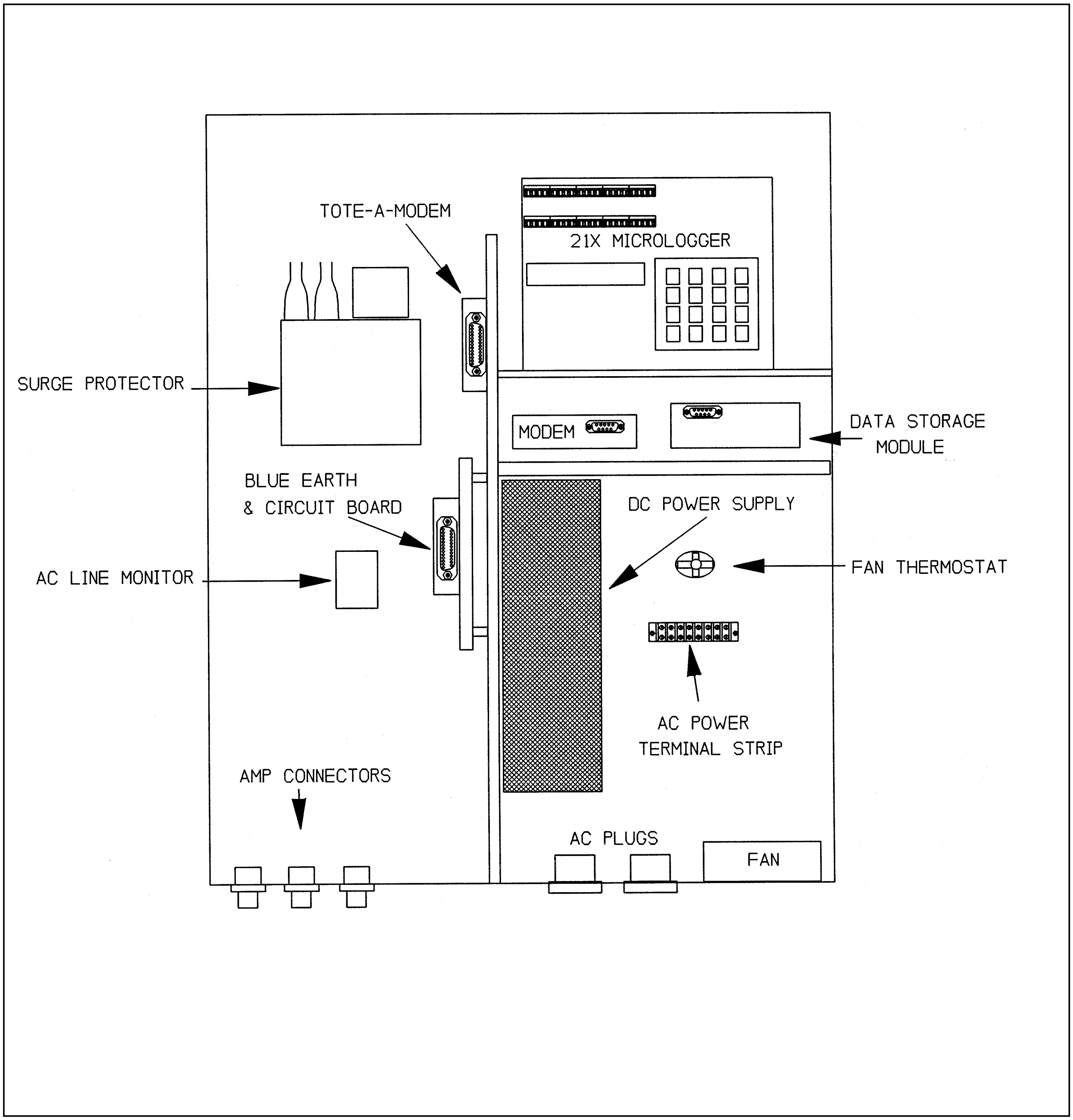


Figure 4-4. Data Logging and Control Subsystem Component Locations.

4.3.2 Definitions of Wiring Abbreviations

The following abbreviations are used to reference components and connectors:

21X	-	Campbell 21X micrologger
A1	-	Nephelometer analog channel 1
A2	-	Nephelometer analog channel 2
A,B,C, etc.	-	Connectors on interface circuit board
AC	-	AC line monitor
ACL	-	AC Line monitor
AMP	-	AMP-type connectors on bottom of enclosure
AT	-	Ambient Temperature
BE	-	Blue Earth microcontroller
CAO	-	Control Analog Output signal from 21X datalogger
CB	-	Interface Circuit Board (with Blue Earth microcontroller)
DB9	-	DB9-type connector for laptop computer on bottom of enclosure
DCP	-	Data Collection Platform
DTR	-	Data Terminal Ready signal from 21X datalogger to Blue Earth microcontroller
EXC	-	21X Excitation channel
FP	-	Front Panel
FPTS	-	Front panel terminal strip
GND	-	Ground
LCD	-	Liquid crystal display on front panel
N/C	-	Not Connected
NEPH	-	Nephelometer
PS	-	Power supply
RH	-	Relative Humidity
RX	-	RS-232 Receive signal
TM	-	Tote-a-modem
TX	-	RS-232 Transmit signal
TSP	-	Telephone Surge Protector

4.3.3 Connector Panel Connector Locations

The connector panel on the data logging and control subsystem is on the underside of the enclosure. Figure 4-5 is a view of the connector panel from above and inside the enclosure. The connectors are standard male 4- and 9-pin AMP type.

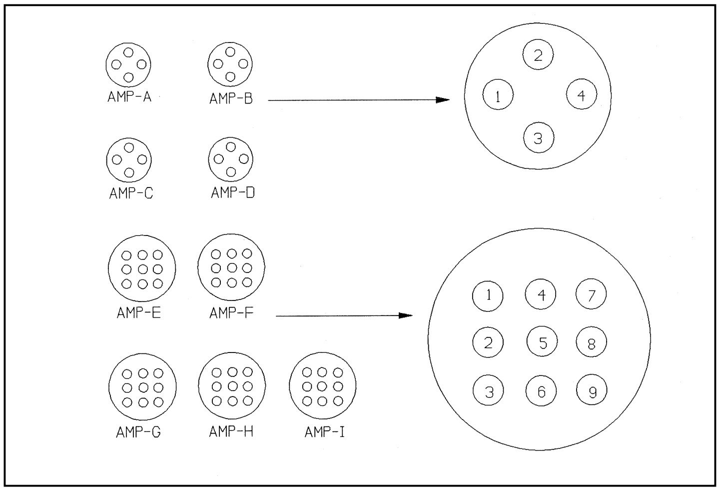


Figure 4-5. Data Logging and Control Subsystem Connector Panel.

4.3.4 Connector Panel Wiring

Table 4-3 details the wiring related to connectors A,C,F,H and I. Connectors B,D,E,and G are not currently used.

4.3.5 Interface Circuit Board

Figure 4-6 shows the layout of the interface circuit board. Tables 4-4 and 4-5 detail the wiring related to the Interface Circuit Board (CB).

4.3.6 Front Panel Wiring

The enclosure front panel includes the following components as shown in Figure 4-7:

- Red neon AC power indicator
- Green incandescent 13.8 VDC power indicator
- Momentary 13.8 VDC power interrupt pushbutton switch
- LCD display
- AC and DC fuses
- Terminal strip connector block

Table 4-6 provides the manufacturer, supplier, and part number for the front panel components. Wiring for the front panel is diagrammed in Figure 4-7.

Table 4-3

Connector Panel Connector Wiring

AMP Connector Pins and Wires			
Pin #	Function	Color	To/From
AMP-A Connector - External Nephelometer Computer Terminal (To/From CB - L)			
1	Ground	Black/Red	L3, DB9-5
2	Neph RX	Blue/White	L1, DB9-2
3	Neph TX	Red/White	L2, DB9-3
4	N/C	-	-
AMP-C Connector - Telephone (To/From CB-F)			
1	N/C	-	-
2	Phone	Red	Through TSP to CB-F1
3	N/C	-	-
4	Phone	Green	Through TSP to CB-F3
AMP-F Connector - Output to DCP (From CB-N)			
1	Neph Analog A1-	Green/White	N2
2	Neph Analog A1+	Red	N3
3	Neph Analog A2-	Orange/Black	N4
4	Neph Analog A2+	White/Black	N5
5	N/C	-	-
6	N/C	-	-
7	CAO #2 GND	White/Red	21X CAO GND
8	CAO #2 Signal	Blue/Red	N1
9	N/C	-	-
AMP-H Connector - Rotronics AT/RH Sensor and Fan (From CB-B)			
1	Fan 12 VDC Supply	Orange/Red	B1
2	Fan 12 VDC Return	Red/Black	B2
3	N/C	-	-
4	AT Signal	Green/Black	B7
5	RH Signal	Green/Black/White	B6
6	N/C	-	-
7	8 to 30 VDC Sensor Power	Black/White	B3
8	Sensor Common	Red/Green	21X Excitation GND
9	N/C	-	-
* Orange/Green Tied Back - N/C			
AMP - I Connector - NGN-2 Nephelometer (From CB-G and FP 12 VDC)			
1	Neph Power (13.8 VDC)	Red (16 GA)	FP3
2	Neph Power Return	Black (16 GA)	FP4
3	RX	Blue/Black	G3
4	GND	Orange	G1
5	TX	Black	G2
6	A1+	Blue	G6
7	A1-	White/Red/Black	G7
8	A2+	Red/White/Black	G4
9	A2-	Black/White/Red	G5
Orange/Green From CP - B4 Tied Back - N/C			
Red/Green From CP - H8 tied to Orange/Green from 21X EXC GND #2			

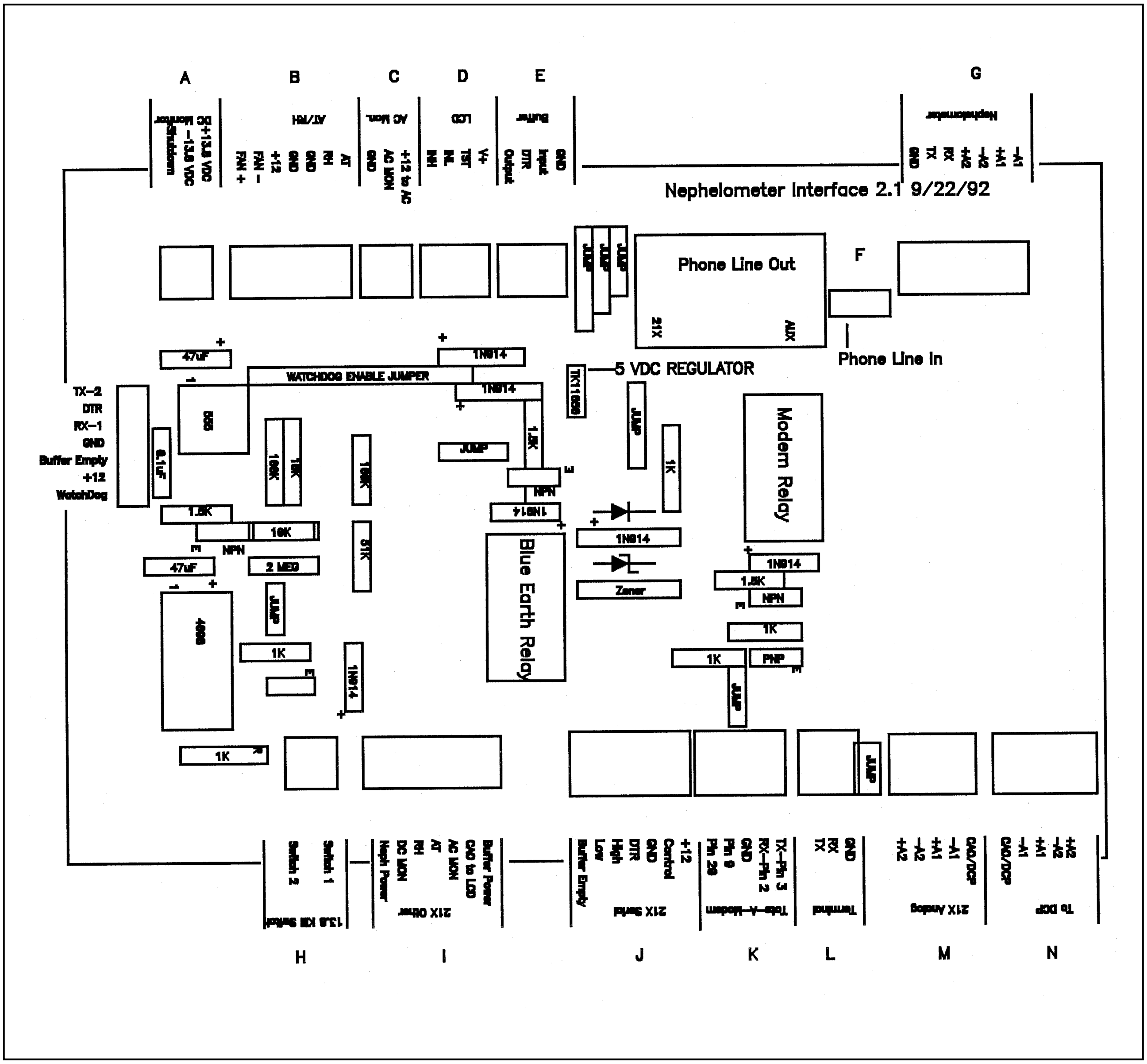


Figure 4-6. Interface Circuit Board Layout.

Table 4-4

Interface Circuit Board (CB) Connector Functions

Interface Circuit Board Connector Functions		
Connector	Function	Comments
A	DC Voltage Monitor	
B	AT/RH	
C	AC Line Monitor	
D	LCD Display	
E	Black Box Buffer	Not Used
F	Phone	
G	Nephelometer	
H	Reset 12 VDC Power	
I	21X Other	
J	21X Serial	
K	Tote - A - Modem	
L	Terminal	
M	21X Analog	
N	DCP	
P1	21X Modem	Phone Plug
P2	Tote - A - Modem	Phone Plug

Table 4-5

Interface Circuit Board Connector Wiring

Interface Circuit Board Connector Wiring			
Pin #	Function	Color	To/From
A Connector - DC Voltage Monitor (From PS)			
1	12 VDC Shut Off	Green	PS - 5
2	13.8 VDC-	Black	PS - 8
3	13.8 VDC+	Red	PS - 9
B Connector - AT/RH Sensor (From CP - H)			
1	Fan +	Orange/Red	AMP-H1
2	Fan -	Red/Black	AMP-H2
3	Sensor Power	Black/White	AMP-H7
4	N/C	Orange/Green	N/C
5	N/C	Red/Green	N/C
6	RH Signal	Green/White/Black	AMP-H5
7	AT Signal	Green/Black	AMP-H4
C Connector - AC Line Monitor			
1	AC Monitor Ground	Black	ACL-1
2	AC Monitor Signal	Orange	ACL-1
3	+12 VDC	Red	ACL-1
D Connector - LCD Display			
1	Input High	Green	LCD-7
2	N/C	-	-
3	N/C	-	-
4	+5 VDC	Red	LCD-1
F Connector - Phone (To/From AMP-C)			
1	Phone	Red	AMP-C2 through TSP
2	N/C	N/C	N/C
3	Phone	Green	AMP-C4 through TSP
G Connector - Nephelometer (From AMP-H)			
1	Ground	Orange	AMP-I4
2	TX	Black	AMP-I5
3	RX	Blue/Black	AMP-I3
4	A2+	Red/Black/White	AMP-I8
5	A2-	Black/White/Red	AMP-I9
6	A1+	Blue	AMP-I6
7	A1-	White/Red/Black	AMP-I7
H Connector - 12 VDC PS Shut Down (To PS)			
1	Switch	Black	FPTS-1
2	N/C	N/C	N/C
3	13.8 VDC	Red, Clear, or White	FPTS-2

-- continued --

Table 4-5 (Continued)

Interface Circuit Board Connector Wiring

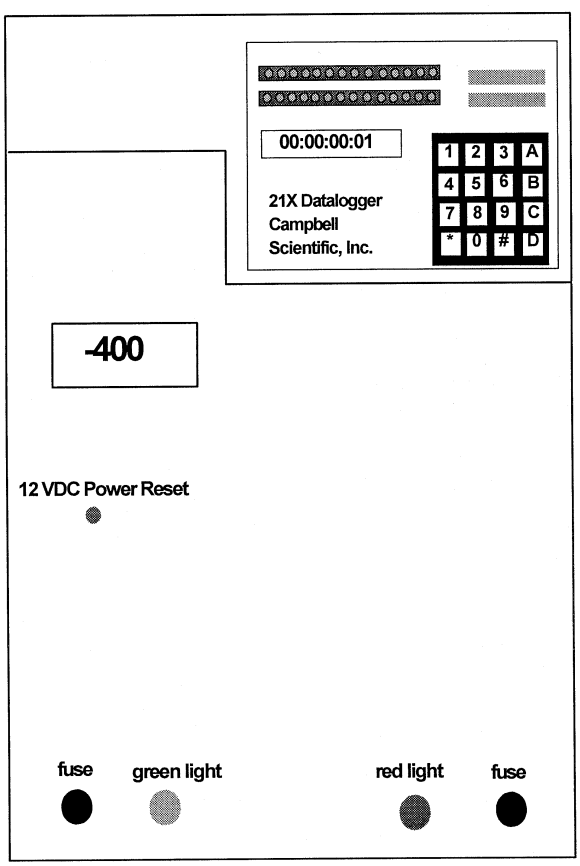
Interface Circuit Board Connector Wiring			
Pin #	Function	Color	To/From
I Connector - 21X Other (To/From 21X)			
1	Neph Relay + Neph Power Monitor	White Red/Black	21X Control 1 21X 5H
2	RH Signal	Blue/Red	21X 4L
3	AT Signal	Orange/Red	21X 4H
4	AC Line Monitor	White/Black	21X Pulse 1
5	CA01 to LCD	Red	21X CAO 1
6	BE Power Relay	Black/Red	21X Control 4
J Connector - 21X Serial (To/From 21X)			
1	Buffer Empty	White/Black/Red	21X 5L
2	Low	Green/White	21X 1L
3	High	Orange/Black	21X 1H
4	DTR	Orange	21X Control 3
5	GRD	Black	21X Power
6	Modem Control	Green	21X Control-2
7	+12	White/Red	21X PWR+12
K Connector - Tote-A-Modem (To/From Auxiliary Modem)			
1	Pin 20	Orange	TM Pin 20
2	Pin 8	Red	TM Pin 9
3	GND	Black	TM Pin 7
4	RX Pin 2	White	TM Pin 2
5	TX Pin 3	Green	TM Pin 3
L Connector - Terminal (To/From AMP A)			
1	Neph RX	Blue/White	AMP-A3, DB9-2
2	Neph TX	Red/White	AMP-A2, DB9-3
3	GND	Black/Red	AMP-A1, DB9-5
M Connector - 21X Analog (To/From 21X)			
1	Neph A2+	Blue/Black	21X 3H
2	Neph A2-	Green/Black	21X 3L
3	Neph A1+	Blue/White	21X 2H
4	Neph A1-	Green/Black/White	21X 2L
5	CA01 to DCP	Blue	21X CAO 2
N Connector - DCP (To CP-F)			
1	CA02 (DCP)	Blue/Red	AMP - F8
2	A1-	Green/White	AMP - F1
3	A1+	Red	AMP - F2
4	A2-	Orange/Black	AMP - F3
5	A2+	White/Black	AMP - F4
6	N/C	White/Red	N/C

Table 4-6

Major Components on the Data Logging and Control Subsystem Front Panel

Major Components on the Front Panel			
Category	Manufacturer	Supplier	Model
Green indicator	IDI	Digikey	1090D5-12V
Red indicator	IDI	Digikey	1030QD1
Fuse holder	Digikey	Digikey	F012-ND
Pushbutton switch	Augat	Newark	MSPF-101C
LDC Display	Jewel	Digikey	5900102141

Datalogger support system front panel.



Front panel wiring schematic.

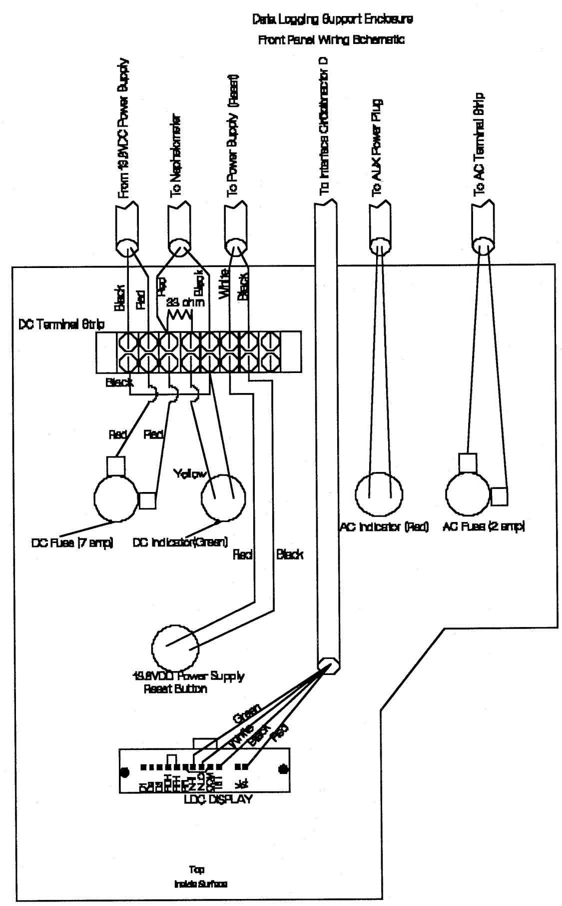


Figure 4-7. Datalogger Support System Front Panel.

4.3.7 AC Wiring

AC wiring for the enclosure includes the following components:

- Male twist-lock plug
- Female twist-lock socket
- AC surge protector
- Terminal strip
- Fuse

Table 4-7 provides the manufacturer, supplier, and part number for the AC wiring components. The AC wiring is diagrammed in Figure 4-8.

Table 4-7

Major Components of AC Wiring for Data Logging and Control Subsystem

Major Components of the Data Logging and Support System AC Wiring			
Category	Manufacturer	Supplier	Model
Male AC plug	GE	Loos Electric	GL0525
Female AC socket	GE	Loos Electric	GL0524
Fuse holder	Digikey	Digikey	F012-ND
Surge Protector	Stabiline	Newark	PQI-1115

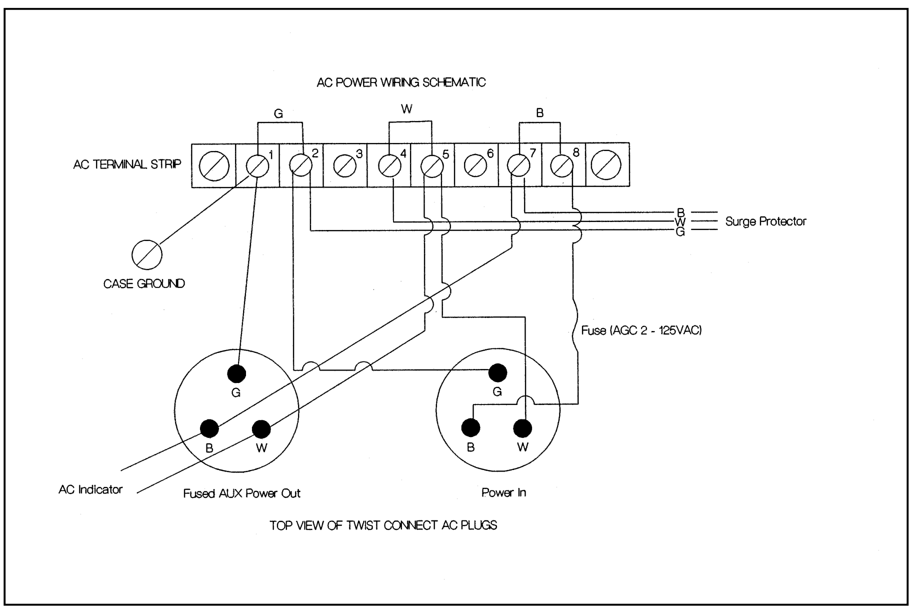


Figure 4-8. Data Logging and Control Subsystem AC Wiring Diagram.

4.3.8 13.8 VDC Power Supply

The 13.8 VDC power supply provides power to the following components:

- Nephelometer
- AT/RH aspiration fan
- Data logging and control subsystem ventilation fan

Table 4-8 provides information on the wiring of the 13.8 VDC power supply terminal strip. The function of each screw terminal is indicated on the power supply.

Table 4-8

13.8 VDC Power Supply Terminal Strip Wiring

Terminal Strip Wiring			
Position #	Function	Color	To/From
1	AC Ground	Green -14 GA	AC Plug
2	AC Neutral	White (Black)-14 GA	AC Plug
3	AC Line	Black (Brown) -14 GA	AC Plug
4	Sig Ground	N/C	-
5	Shut Down	Green	CB - A1
6	Sense	N/C	-
7	Output-	Black	FP DC - Fuse
8	Output-	Black Black	CB - AZ (two)
9	Output+	Black Red	Therm Therm
10	Output+ Sense+	Red	CB - A3
11	Output+ Sense+	N/C	FP DC Fuse

Notes:

1. Positions 1, 2, and 3 plug from the AC power cord into the surge protector.
2. Positions 5, 8, and 9 plug from CB - through the hole in the center shelf support.
3. Positions 7 and 10 plug to the front panel fuse/indicator through the hole in the center shelf support.
4. Positions 8 and 9 plug into the thermostat/fan.

4.3.9 Campbell 21X Datalogger Wiring

The Campbell 21X datalogger performs all measurements and controls the functions of the data logging and control subsystem. Figure 4-9 shows the locations of the terminals on the datalogger. Table 4-9 details the wiring connections to the datalogger.

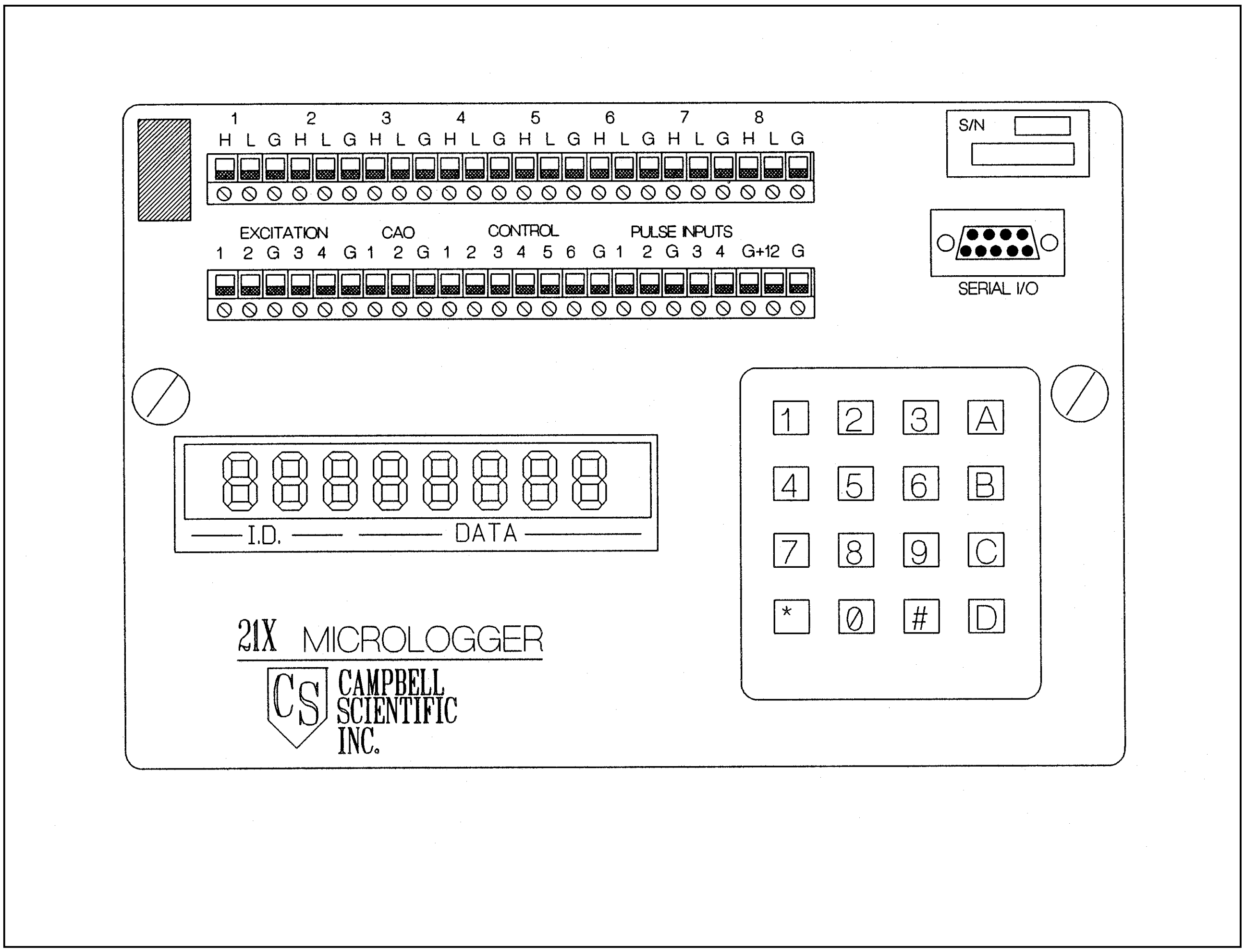


Figure 4-9. Campbell Scientific 21X Datalogger.

Table 4-9

Campbell 21X Datalogger Wiring Description

Sensor Connector - 9-Pin AMP Female		
Terminal	To/From	Color
1H	Serial High	Orange/Black
1L	Serial Low	Green/White
2H	Neph A1 +	Blue/White
2L	Neph A1 -	Green/Black/White
3H	Neph A2 +	Blue/Black
3L	Neph A2 -	Green/Black
4H	AT	Orange/Red
4L	RH	Blue/Red
5H	Neph Power Monitor	Red/Black
5L	Buffer Empty from Blue Earth	White/Black/Red
EXCITATION 1	N/C	
EXCITATION 2	N/C	
EXCITATION GND	AT/RH Common	Red/Black/White
EXCITATION 3	N/C	
EXCITATION 4	N/C	
EXCITATION GND	N/C	Orange/Green
CAO 1	LCD	Red
CAO 2	DCP Output	Blue
CAO GND	DCP Output Common	Red/White
CONTROL 1	Neph Relay Control	White
CONTROL 2	Modem Relay Control	Green
CONTROL 3	Serial DTR to Blue Earth	Orange
CONTROL 4	Blue Earth Power Relay	Black/Red
CONTROL 5	N/C	
CONTROL 6	N/C	
CONTROL GND	N/C	
PULSE INPUT 1	AC Line Monitor	White/Black
PULSE INPUT 2	N/C	
PULSE INPUT GND	N/C	
PULSE INPUT 3	N/C	
PULSE INPUT 4	N/C	
PULSE INPUT GND	N/C	
+12	Power to Interface Board	White/Red
GND	Power Return	Black

4.3.10 Nephelometer Power and Signal Cable

The nephelometer power and signal cable provides the following functions for the nephelometer:

- DC Power (13.8 VDC, 7 amps)
- RS-232 serial I/O (RX, TX, GND)

- Two analog output channels (A1, GND, A2, GND)

The cable assembly consists of the following components:

- 2-Conductor, 14-AWG cable for 13.8 VDC, 7 amp power
- 9-Conductor, 22 AWG cable for serial and analog data lines
- Two 9-Pin AMP connectors (one on each end of the cable)

Table 4-10 details the cable wiring pin and wire color assignments.

Table 4-10

Nephelometer Power and Signal Cable

Power and Signal Cable			
Pin #	Function	Color	Wire Type
1	13.8 VDC Power	Red	14 AWG
2	Power Return	Black	14
3	RX to Neph	White	22 AWG
4	Common	Black	22
5	TX from neph	Red	22
6	Analog 1 +	White/Black	22 AWG
7	Analog 1 -	Blue	22
8	Analog 2 +	Green	22
9	Analog 2 -	Orange	22

4.4 SHIELDED AND ASPIRATED ROTRONICS AMBIENT TEMPERATURE AND RELATIVE HUMIDITY SENSOR

The AT/RH sensor is used to provide weather parameter information and also to use as a quality assurance measure to compare with scattering measurements. Figure 4-10 shows an exploded view of the sensor and shield.

4.4.1 <u>Major Components</u>

The Rotronics AT/RH Sensor system includes the following components:

- Rotronics AT/RH Sensor (Model MP-100F)
- Force-aspirated shield
- Aspiration fan
- Cable assembly

Table 4-11 provides the manufacturer, supplier, and part number for the AT/RH system components.

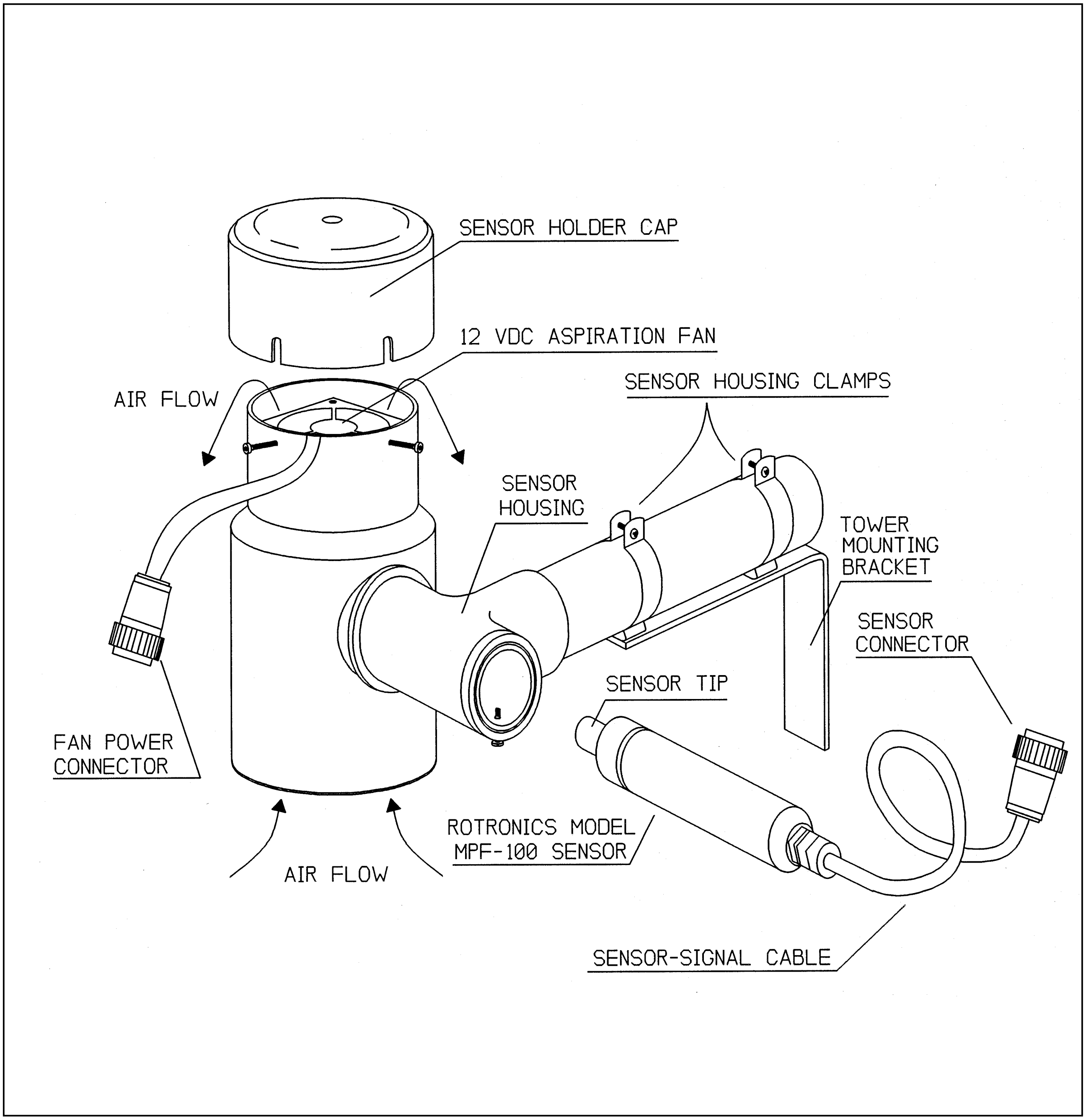


Figure 4-10. Rotronics AT/RH Sensor in Force-Aspirated Shield.

Table 4-11

Major Components of the Shielded and Aspirated Rotronics AT/RH Sensor System

Major Components of the Rotronics AT/RH Sensor System			
Category	Manufacturer	Supplier	Model
AT/RH Sensor	Rotronics	Rotronics	MP-100F
Shield (force-aspirated)	ARS Technologies	ARS Technologies	
Aspiration fan, 12 VDC,0.06A,0.72W	ComAir	Digikey	FS12H3

4.4.2 Rotronics AT/RH Sensor and Aspiration Fan Connector and Cable

Table 4-12 describes the Rotronics AT/RH sensor and aspiration fan connector and cable.

Table 4-12

Rotronics AT/RH Sensor and Aspiration Fan Connector and Cable Wiring

Rotronics AT/RH Sensor and Fan Connectors and Wiring		
Pin #	Function	Color
Sensor Connector - 9-Pin AMP Female		
1	Fan 12 VDC Supply	Red
2	Fan 12 VDC Return	Black
3	N/C	-
4	Air Temperature	White
5	Relative Humidity	Green
6	N/C	-
7	8 to 30 VDC Sensor Power	Red
8	Sensor Common	Black and Shield
9	N/C	-
Fan Connector - 4-Pin AMP Female		
1	Fan 12 VDC Supply	Red or White
2	Fan 12 VDC Return	Black
3	N/C	-
4	N/C	-

Notes:

1. Two cables run from the connector panel connector (H) to the AT/RH sensor holder. The fan power cable may be terminated at another connector (see Table 4-12 (4-Pin)).
2. Do not shorten the cable from the Rotronics AT/RH sensor - a change in calibration may occur.
3. The 12 VDC fan should be connected to draw air from the bottom of the sensor holder.
4. The white ceramic sensor cover protecting the Rotronics sensor elements should be centered within the holder column.
5. Fan wires have the + (red or white) towards the point of the female connector.

4.5 SUPPORT TOWER AND RELATED HARDWARE

4.5.1 Major Components

The support tower and related hardware include the following:

- A 10 or 14 foot Rohn tower
- Guy wires and related hardware
- A Rohn tower base

4.5.2 Tower-Related Components

The tower and related components provide a suitable location for mounting the nephelometer (using the precipitation and solar radiation shield), data logging and control subsystem, and other components. Tower-related components include:

- A 10 foot or 14 foot (2 7-foot sections) Rohn tower and related components
- A Rohn tower base
- Guy wires
- Turnbuckles, links, and clamps
- Construction stakes with welded nuts

Figure 4-11 shows a typical tower setup including a tower and related hardware.

4.5.3 Wall Mount Option

The nephelometer can be mounted to a wall using special wall-mount brackets. The wall-mount brackets support the precipitation and solar radiation shield that supports the nephelometer.

4.6 PRECIPITATION AND SOLAR RADIATION SHIELD

The precipitation and solar radiation shield provide the following functions:

- A secure elevated location to mount the nephelometer
- Protection from direct precipitation
- Protection from direct solar radiation
- Pulleys for easy installation and removal of the nephelometer

Figure 4-12 details the nephelometer precipitation and solar radiation shield and its tower mounting configuration. Figure 4-13 details the precipitation hood.

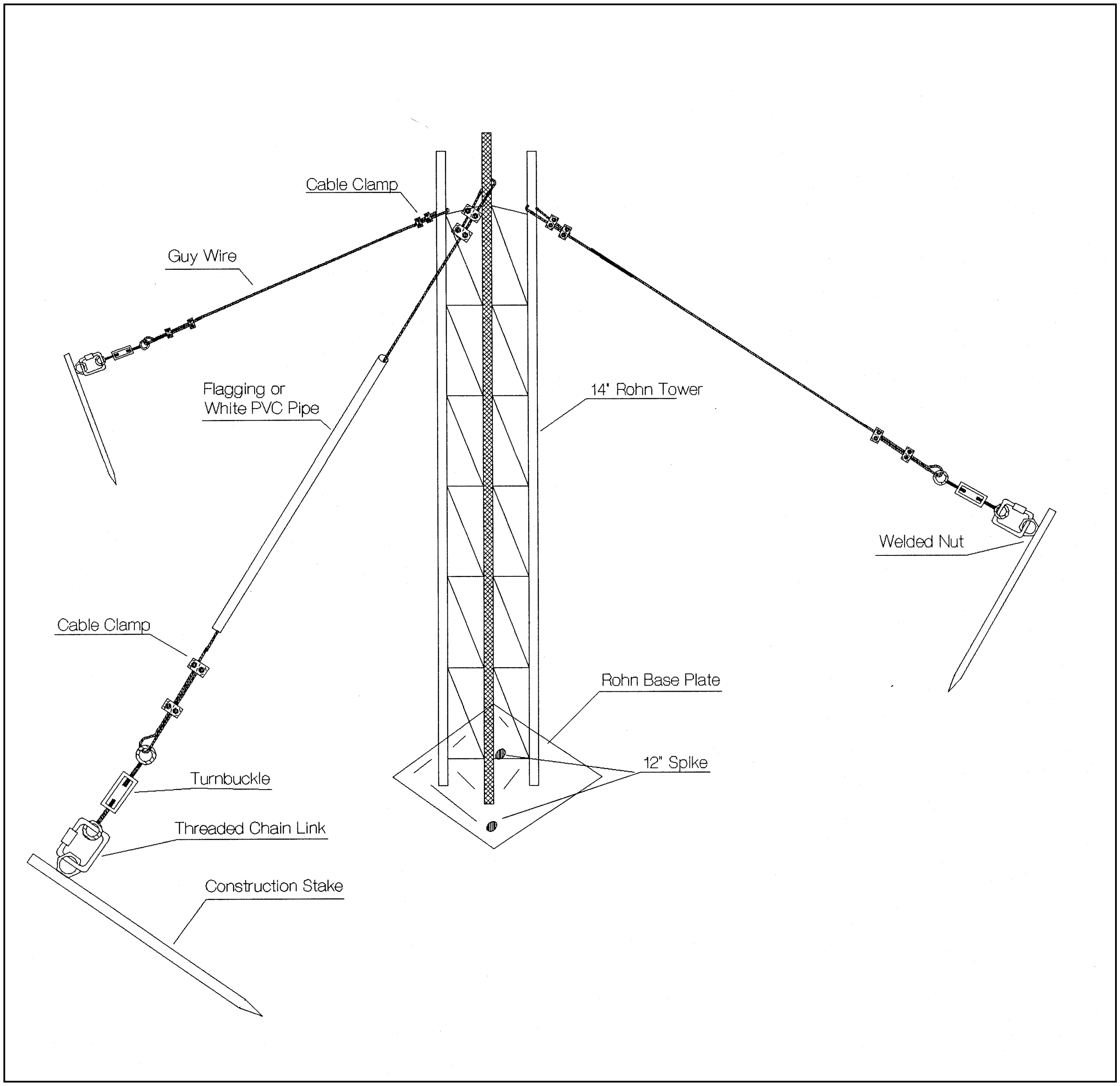


Figure 4-11. Nephelometer Support Tower and Related Hardware.

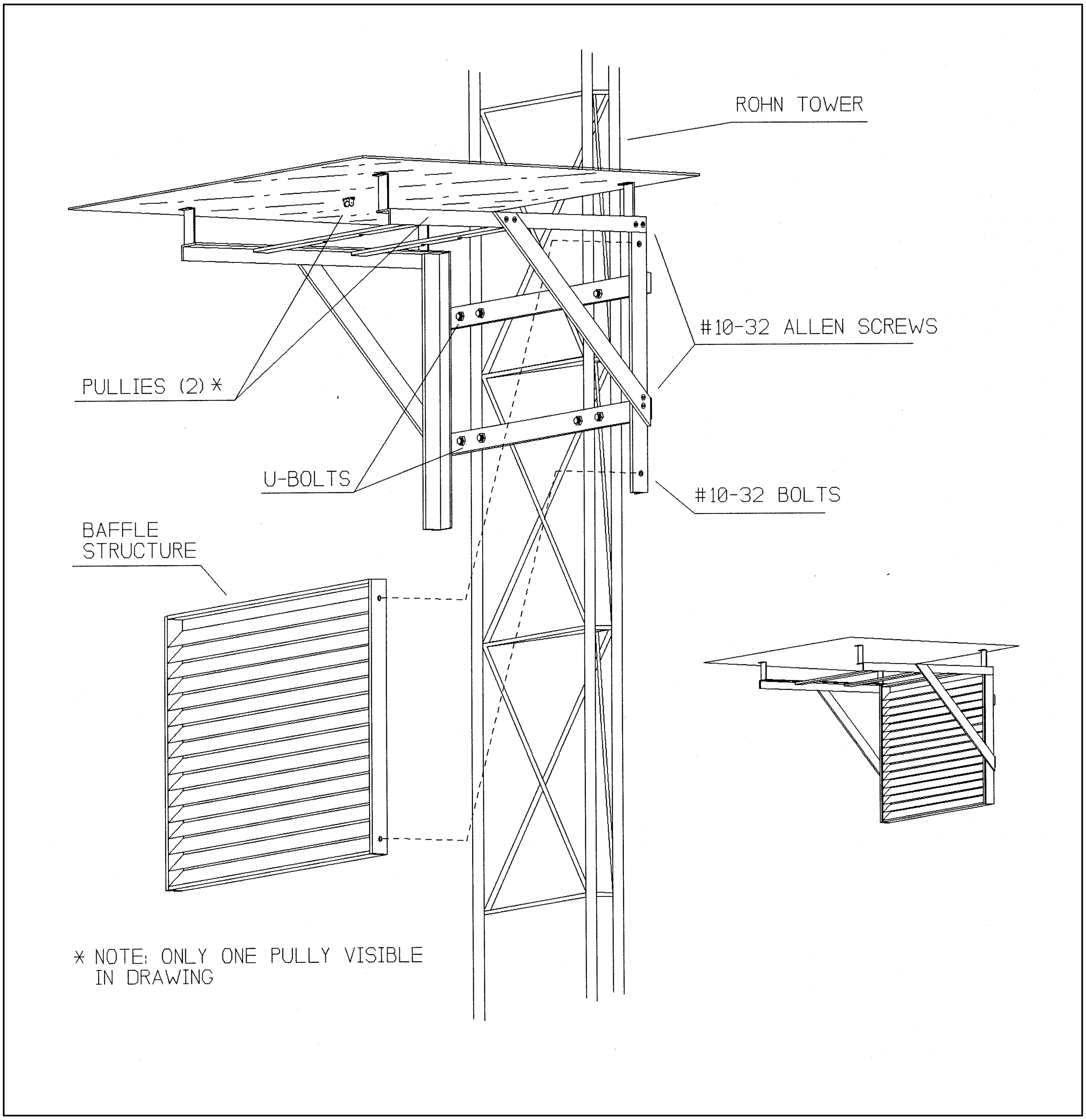


Figure 4-12. Precipitation and Solar Radiation Shield for Optec NGN-2 Nephelometer.

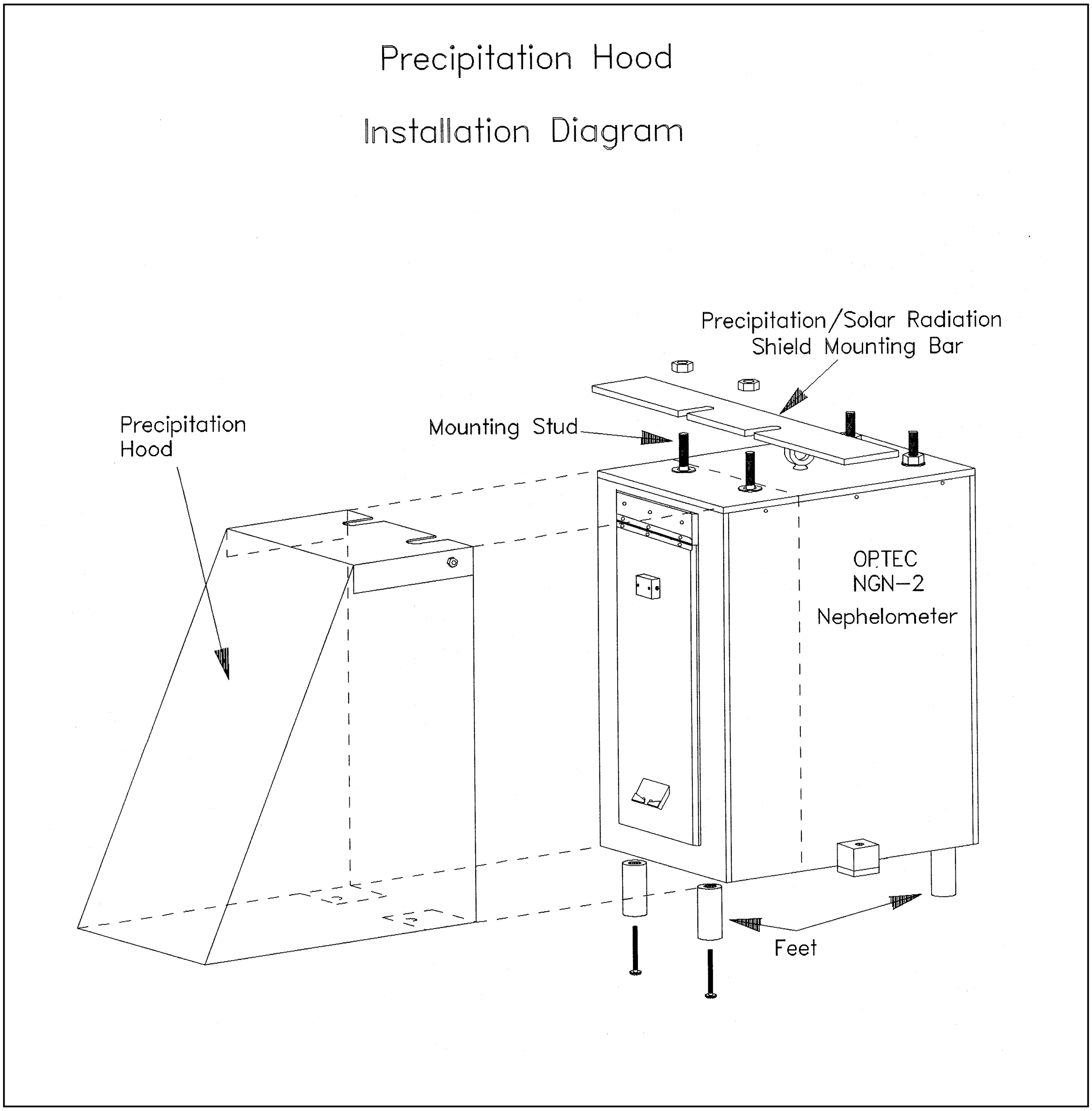


Figure 4-13. Precipitation Hood Installation Diagram.

5.0 REFERENCES

Optec, Inc. 1993, Model NGN-2 Open-Air Integrating Nephelometer, Technical Manual for Theory of Operation and Operating Procedures. Revision 4, November. Lowell, MI.

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TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4100-3375**
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AUTHORIZATIONS

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REVISION HISTORY

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0.1	Modifications to log sheet.	April 1995	
1.0	Diagram and minor text changes.	October 1996	

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LIST OF FIGURES (CONTINUED)

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes procedures for removing, installing, and proper packing and shipping of nephelometer system components and support equipment at a field monitoring site.

This TI, as referenced in Standard Operating Procedure (SOP) 4100, *Nephelometer Maintenance (IMPROVE Protocol)*, specifically describes:

- Procedures for disconnecting power from instruments and support equipment.
- Procedures for removing instruments and support equipment from mounting hardware.
- Cables and other accessories to be packed and shipped with instruments and support equipment.
- Removal documentation requirements for instruments and support equipment.
- Procedures for installing replacement instruments and support equipment.
- Procedures for connecting power to instruments and support equipment.
- Procedures for verifying and documenting proper operation of replacement instruments and support equipment.
- Procedures for packing instruments and support equipment for shipment.
- Shipping methods required for each item.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Coordinate with the site operator, his/her supervisor, field specialist, and data coordinator concerning the schedule and requirements for specific nephelometer component replacement and shipment procedures.
- Oversee and review specific nephelometer component replacement and shipment procedure documentation completed by the site operator for accuracy and completeness.

2.2 FIELD SPECIALIST

The field specialist shall:

- Coordinate with the site operator, his/her supervisor, project manager, and data coordinator concerning the schedule and requirements for specific nephelometer component replacement and shipment procedures.

- Train the site operator in all phases of specific nephelometer component replacement and shipment procedures necessary for on-site resolution of instrument problems.

- Provide technical support to the site operator via telephone to assure proper nephelometer component replacement and shipment procedures.

- Document all technical support provided to the site operator.

- Resolve problems reported by the site operator.

2.3 DATA COORDINATOR

The data coordinator shall:

- Coordinate with the site operator, his/her supervisor, project manager, and field specialist concerning the schedule and requirements for specific nephelometer component replacement and shipment procedures.

- Identify possible instrument malfunction and contact the site operator to schedule a visit for nephelometer component replacement and shipment procedure implementation.

- Review documentation completed by the site operator for accuracy and completeness.

- Verify that scheduled visits are performed and notify the site operator if he/she fails to make a scheduled visit.

- Provide technical support to the site operator via telephone to assure proper nephelometer component replacement and shipment procedures.

- Document all technical support provided to the site operator.

- Review and file all site documentation.

- Resolve problems reported by the site operator.

- Send supplies, tools, and replacement instrumentation necessary for instrument problem resolution to the site operator.

- Make the necessary arrangements for pick up and return shipment of malfunctioning nephelometer components.

- Enter all correspondence with the site operators and the results of all performed procedures into site-specific timelines.

2.4 SITE OPERATOR

The site operator shall:

- Coordinate with his/her supervisor, project manager, field specialist, and data coordinator concerning the schedule and requirements for specific nephelometer component replacement and shipment procedures.

- Perform all field-related procedures described in this TI.
- Thoroughly document all nephelometer component replacement and shipment actions on the NGN-2 Nephelometer/Meteorology Log Sheet and mail the log sheet to the data coordinator.
- Report any noted inconsistencies immediately to the data coordinator or field specialist.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The following equipment is generally required for nephelometer component replacement and shipment:

- Keys for shelters and padlocks
- 30' nephelometer hoisting rope with hook
- NGN-2 Nephelometer/Meteorology Log Sheet
- Pen or pencil
- Site Operator's Manual for Nephelometer Systems
- Small, medium, and large flat-blade screwdriver
- Medium adjustable wrench
- Electrical tape
- Pliers
- Blower (photographic) brush
- Cleaning cloth
- Nephelometer shipping case or box
- Support equipment shipping cases or boxes
- Packing material
- ARS shipping labels
- Packing tape

4.0 METHODS

This section includes three (3) major subsections:

4.1 Nephelometer and Support Equipment Removal
4.2 Nephelometer and Support Equipment Installation
4.3 Packing and Shipping

4.1 NEPHELOMETER AND SUPPORT EQUIPMENT REMOVAL

The following subsections describe the procedures for disabling and removing the nephelometer and support equipment. The subsections include:

- Removing the Optec NGN-2 nephelometer
- Removing the Handar 540 DCP
- Removing the data logging and control subsystem
- Removing the Rotronics air temperature/relative humidity sensor

4.1.1 Removing the Optec NGN-2 Nephelometer

Take the appropriate shipping case or box to the site when removing the nephelometer so the instrument will be protected during transit. See Section 4.3 for packing and shipping instructions. Removing the instrument is much easier with two people, so bring help to the site if possible.

DISCONNECT

Reset the power to the nephelometer so the nephelometer door will close. Shipping the instrument with the door closed is preferred. If all power systems have failed this may not be possible.

Disconnect the signal/power cable from the back of the nephelometer. Tape the end of the cable connector with electrical tape and allow the connector to hang down to prevent moisture from entering.

Disconnect the span gas hose from the back of the nephelometer.

REMOVE

Attach the nephelometer hoist rope hook to the circular hook on top of the nephelometer. Feed the rope through the two (2) pulleys on the underside of the precipitation/solar radiation shield and extend the rope to ground level. Refer to Figure 4-1, Optec NGN-2 Nephelometer Exterior Diagram, for location of the hoist rope hook.

Take up all slack in the rope and TIE THE ROPE SECURELY TO THE TOWER NEAR THE GROUND.

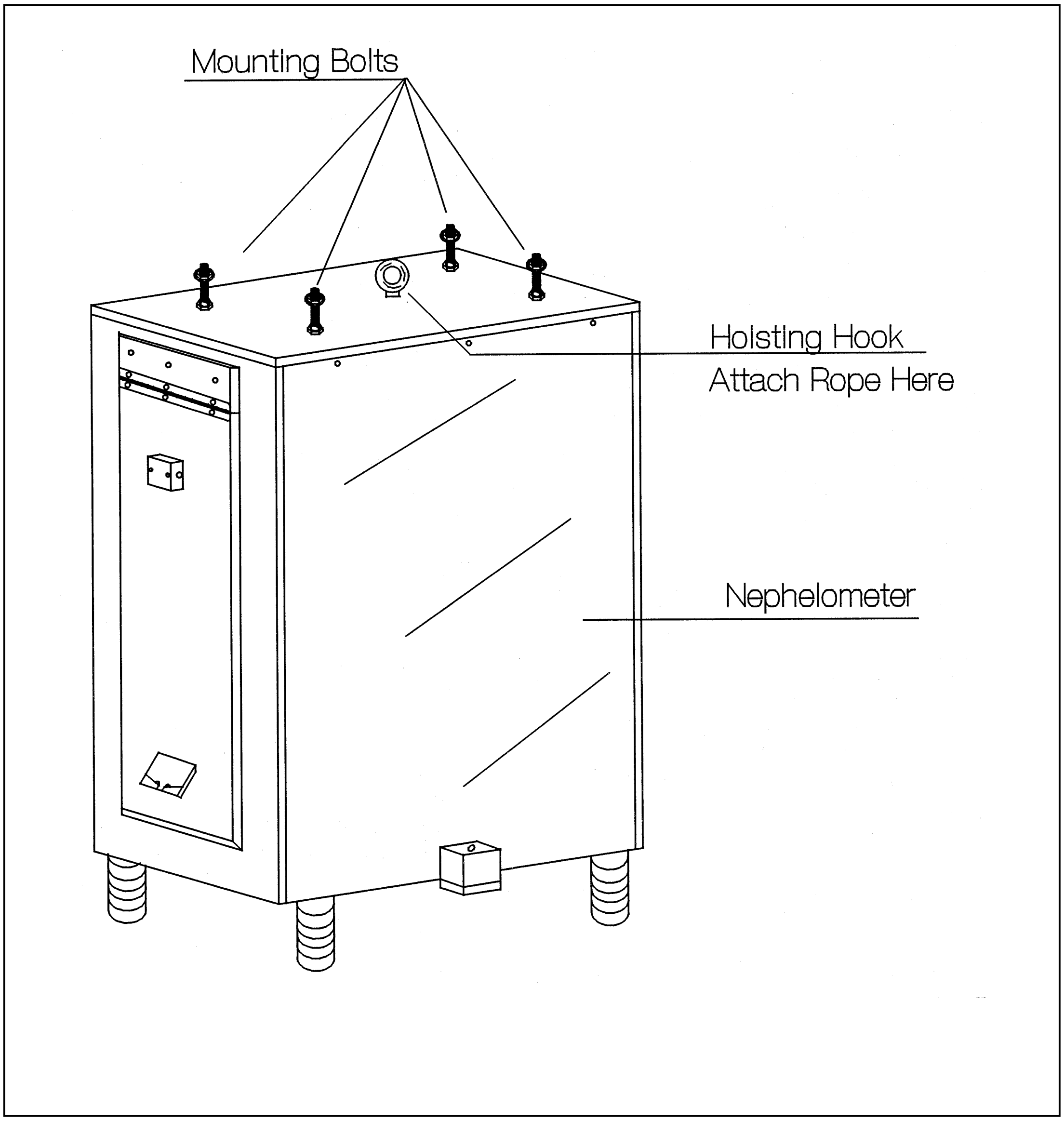

Figure 4-1. Optec NGN-2 Nephelometer Exterior Diagram.

Loosen (but do not remove) the four (4) nuts holding the nephelometer to the precipitation/solar radiation shield and slide the nephelometer out of the mounting slots. Be certain that the rope will hold the nephelometer.

Use the rope to lower the nephelometer carefully to the ground.

Carefully pack the nephelometer in the shipping case or box. Be sure to use sufficient packing material to protect the nephelometer during transit.

DOCUMENT — Document removal of the instrument on the operator log sheet. Figure 4-2 is an example NGN-2 Nephelometer/Meteorology Log Sheet.

4.1.2 <u>Removing the Handar 540 DCP</u>

Take the appropriate shipping case or box to the site when removing the DCP so the instrument will be protected during transit. See Section 4.3 for packing and shipping instructions. Figure 4-3 depicts the DCP datalogger component diagram and details the location of the switches and connectors discussed in this section.

IMPORTANT: Before disconnecting the DCP antenna cable, some internal switch settings must be changed to inhibit transmissions. Failure to do so will damage the DCP.

Follow the procedures below when removing the DCP:

RESET — Loosen the clasps and open the hinged door of the DCP. Locate the six (6) red, square, dial switches located on the circuit board on the inside of the DCP door. Refer to close-up of dial switches in Figure 4-3.

Using a small flat-blade screwdriver, reset the switches under "CHAN 1" to **9, 0, 0**. The switch immediately below the "100" on the circuit board should be set to **9**. The switches immediately below the "10" and the "1" on the circuit board should be set to **0**.

Close the DCP door and tighten the clasps.

DISCONNECT — Before disconnecting the connectors on the side of the DCP, note their locations and mark if necessary. Draw a wiring diagram if it will be helpful. Refer to Figure 4-3.

Disconnect all cables from the DCP input panel and tape the ends of the cables with electrical tape. Allow the connectors to hang down to prevent moisture from entering.

REMOVE — Remove the DCP by loosening the tower mounting bolts.
Pack the unit for shipping in the supplied box.

DOCUMENT — Document the removal of the DCP on the log sheet.

Air Resource Specialists, Inc.

Location ____________________

NGN-2 NEPHELOMETER/METEOROLOGY LOG SHEET

Date ____________________ Local Time ______:_______ ( ) Operator(s) ______________________________
Weather Conditions (Temperature, Wind, Precipitation) ______________________________
Visibility Conditions ______________________________

Support Tower, Guy Wires and/or Other Structural Components

1. Physical condition:______________________________

AC and DC Power Indicator Lamps

1. Status of the red AC indicator lamp: **ON** **OFF** If off, replace AC fuse (2-amp) and note time _____:______:____
2. Status of the green DC indicator lamp: **ON** **OFF** If off, replace DC fuse (7-amp) and note time _____:______:____

Datalogger

1. General Physical Condition: ______________________________
2. The support system front panel display will show a NEGATIVE number to indicate certain nephelometer operating problems. If the display is approximately one of the following values, perform the action listed and note the time.

Display	Problem	Action	Time (HH : MM)
-400	Lamp burned out	Replace nephelometer lamp, then push red reset button on the support front panel for 5 seconds	______:______
-500	Rain event	None required	______:______
-600	Bad chopper motor frequency	Push red reset button on support system front panel	______:______
-900	Serial data interface failure	Call ARS	______:______

3. Record the following parameters from the datalogger:

Key Sequence	Display	Measurement Parameter	
*64A	04: _________	Nephelometer status code: 1 = good read (ambient), 2 = clean air (zero calibration), 3 = span calibration, 4 = lamp out, 5 = rain, 6 = chopper	
A	05: _________	Nephelometer ambient reading (Reading must be > than last zero (*612A))	
*68A	08: _________	Nephelometer power supply (VDC)	**Call ARS if power is less than**
A	09: _________	Campbell 21X internal battery voltage (VDC)	**12 volts or greater than 15 volts**.
*611A	11: _________	b_{scat} (km^{-1}) or problem code. Does this match front panel display? (Call ARS if it does not)	
*617A	17: _________	Nephelometer lamp intensity (counts)	**Call ARS if counts are below 1500**

4. Check the datalogger date and time: **Note: The 21X datalogger is always kept on Standard Time.**
   a. Synchronize your watch with NBS (WWV) time. (303-499-7111)
   b. Record time on your watch (HH:MM:SS) _____:_____:_____
   c. Record datalogger date and time:

Key Sequence	Current Display	
*5	_____:______:_____	Current time (HH:MM:SS)
A	05:_______________	Year
A	05:_______________	Julian date

   d. IF DATE IS INCORRECT OR TIME DIFFERS BY MORE THAN 1 MINUTE FROM NBS TIME, CALL ARS
   e. Return datalogger to run mode:

Key Sequence	Display
*0	LOG12

Nephelometer

1. General physical condition :______________________________
2. Condition of the inlet screen and door gasket: ______________________________
   (If the screen or gasket is obstructed, call ARS for instructions)
3. Sample fan: **ON** **OFF** Condition of the sample fan and fan guard: ____________________
4. Clean air pump: **ON** **OFF**
5. Nephelometer door: **OPEN** **CLOSED**
6. Lamp cycling at the 2-minute ON, 3-minute OFF schedule? **YES** **NO**
7. Inspect clean air filter: **YES** **NO** Replaced **YES** **NO** Condition of old clean air filter: ________________
8. Remove and inspect light trap: **YES** **NO** Condition of light trap: ____________________

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Figure 4-2. NGN-2 Nephelometer/Meteorology Log Sheet.

9. Calibration - Before beginning calibration, check the *612 and *613 positions on the 21X datalogger (see #11 below).
   *612A Display ___________ *613A Display ___________
   a. Turn flowmeter off (clockwise rotation).
   b. Connect the calibration gas hose to the regulator outlet.
   c. Turn on the span gas tank valve (1/2 turn).
   d. Press and hold the red reset button on the support system front panel for 5 seconds.
   Record the time the red reset button was pressed: _____:_____:_____
   e. The nephelometer will initiate a Power-On Self Test (POST). Document that the POST functions operate correctly:

• Door close and open:	**YES**	**NO**
• Lamp and chopper on:	**YES**	**NO**
• Fan on and off:	**YES**	**NO**
• Solenoid on and off:	**YES**	**NO**
• Clean air pump on and off:	**YES**	**NO**
• Valve on and off:	**YES**	**NO**
• Fan on; solenoid turns on:	**YES**	**NO**
• One-minute ambient reading:	**YES**	**NO**
• Door closes:	**YES**	**NO**

   f. Adjust the span gas regulator pressure control valve to 2-4 psi. Record the pressure: ______________________________
   g. **Slowly** adjust the flowmeter to approximately 20 mm on the Cole Parmer flowmeter. (Make sure the door has been closed for at least 30 seconds before adjusting the flowmeter). Record the flow value: __________ mm
   h. Following the POST, the system will perform a 20-minute span calibration check, followed by a 1-minute span gas purge, followed by a 15-minute clean air zero calibration check.
   i. When the nephelometer door opens (36 minutes after starting the span calibration check) the span and zero calibration checks are complete.
10. TURN THE SPAN GAS TANK VALVE FULLY OFF. Disconnect the calibration gas hose at the regulator outlet to bleed excess gas from the hose, and turn the flowmeter off (clockwise rotation).
11. Record the results of the zero and span calibration checks from the datalogger:

Key Sequence	Display	Measurement Parameter
*612A	12: _________	Last zero calibration check (counts)
A	**13: _________	Last span calibration check (counts) **This number should be slightly different than the *613A reading taken before the calibration check.

Meteorology (Air Temperature/Relative Humidity Sensor; Wind Speed and Wind Direction Sensors)
1. General physical condition:______________________________
2. Wind sensors unobstructed and free moving: **YES** **NO** Comment if NO:____________________
3. AT/RH aspiration fan operating: **YES** **NO** Condition of the AT/RH screen: ____________________
4. Record the following meteorological parameters from the datalogger: **(Note - not all sites have wind speed and wind direction sensors)**

Key Sequence	Display	Measurement Parameter
*61A	01: _________	Ambient temperature (C)
A	02: _________	Ambient relative humidity (%)
*652A	52: _________	Wind speed (mph)
A	53: _________	Wind direction (degrees true)

5. Datalogger values reasonable for current conditions: **YES** **NO** Comment:______________________________

Support System
1. If required, exchange the Campbell SM716 or SM192 storage module with a new one. Record the following:

	Old module	New module
Model (SM192, SM716)	__________	__________
Serial number	__________	__________
Time removed/installed (HH:MM)	_____:_____	_____:_____

2. Complete removal information on the old module's Quality Assurance Card and installation information on the new card.
3. Check all connectors.
4. Call ARS immediately if you have any problems or questions.

General Comments and Supplies Needed

____
____
____
____

FAX and mail the original white 2-page log sheet to:
Leave yellow copy on-site

Air Resource Specialists, Inc.
Attn: Data Coordinator
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525

Phone: 970-484-7941
Fax: 970-484-3423

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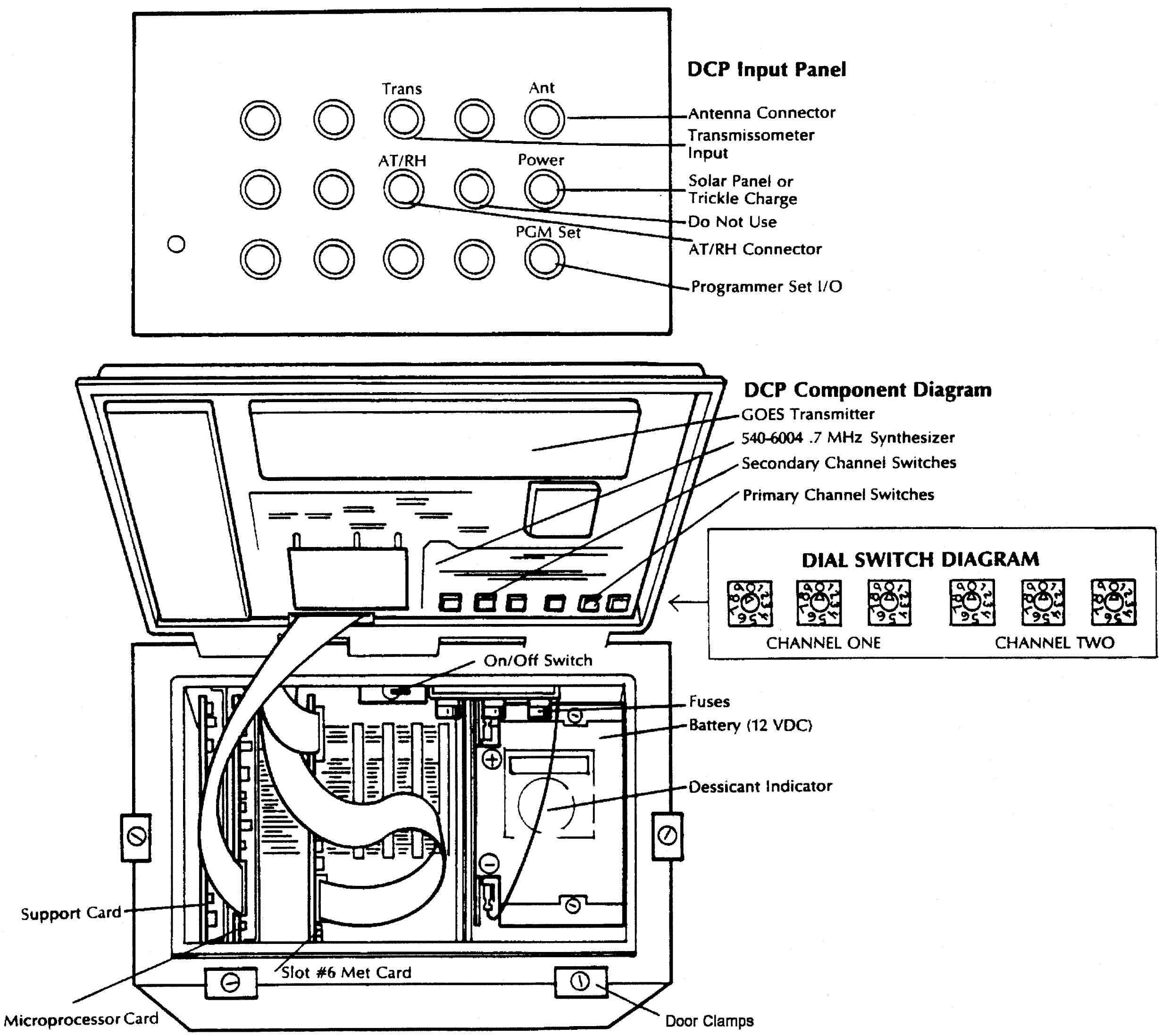
Figure 4-2. (Continued). NGN-2 Nephelometer/Meteorology Log Sheet.



Side View DCP Input Panel

IMPRORTANT--DCP panels may differ from the above unit.

Figure 4-3. Handar 540 DCP Component Diagram.

4.1.3 Removing The Data Logging and Control Subsystem

Take the appropriate case or box to the site when removing the data logging and control subsystem so that the instrument will be protected during transit. See Section 4.3 for packing and shipping instructions. Figure 4-4 is a diagram of the data logging and control subsystem. Follow the procedures below for removal and packing of the enclosure:

DISCONNECT — Disconnect 115 VAC power to the enclosure at the main AC supply (e.g., breaker box or wall plug).

Disconnect all cables from the bottom outside of the enclosure.

Tape the end of each cable connector with electrical tape. Allow the connectors to hang down to prevent moisture from entering.

Open the enclosure and place packing material (bubble-wrap) around the following items to assure they will be secure during transit:

- Campbell datalogger
- Campbell storage module
- Campbell modem
- AC surge protector
- Other loose components

Verify that all components in the enclosure are secure for shipping.

REMOVE — Loosen and remove the four (4) bolts securing the enclosure to the tower, or remove any other mounting screws securing the enclosure.

Carefully pack the enclosure in the shipping case or box using packing material to protect the enclosure during transit.

DOCUMENT — Document the removal of the enclosure on the operator log sheet.

4.1.4 Removing the Rotronics Air Temperature/Relative Humidity Sensor

Follow the procedures below when removing the Rotronics air temperature/relative humidity sensor:

DISCONNECT — The AT/RH sensor is mounted in a fan-aspirated shield. Remove only the sensor; do not remove the shield unless requested by ARS.

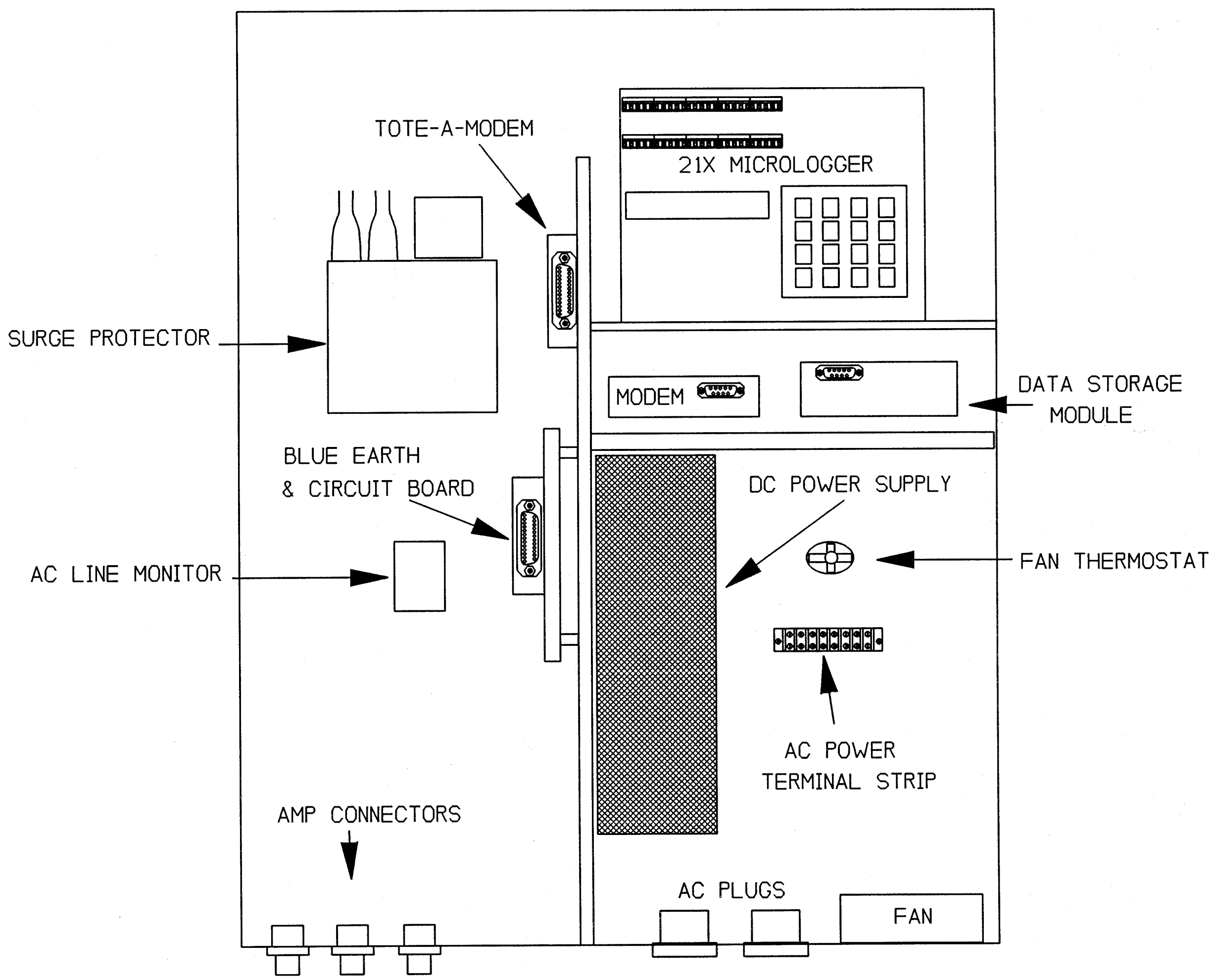


Figure 4-4. Data Logging and Control Subsystem Component Diagram.

Disconnect the air temperature/relative humidity sensor cable at the connection below the sensor (signal cable). See Figure 4-5, Rotronics Air Temperature/Relative Humidity Sensor Component Diagram, and Figure 4-6, AT/RH Sensor/DCP Cable Connection Diagram).

Tape the end of the cable connector with electrical tape. Allow the connector to hang down to prevent moisture from entering.

REMOVE — Loosen the sensor-securing bolt on the AT/RH shield and slide the sensor out of the shield.

Pack the sensor and shield (if requested) in the case or box for shipping.

DOCUMENT — Document the removal of this sensor on the operator log sheet.

4.2 NEPHELOMETER AND SUPPORT EQUIPMENT INSTALLATION

Replacement nephelometer components will be shipped directly to the site operator by ARS. Upon receipt of the shipment, the site operator should follow the component-specific procedures listed below. Additional installation diagrams can be found in TI 4070-3000, *Installation of Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*, and TI 4100-3350, *NGN-2 Nephelometer Monitoring Systems Diagrams and Component Descriptions*.

4.2.1 Installing the Nephelometer

Follow the procedures below when installing the nephelometer:

INSTALL — Leave the nephelometer in the shipping case or box until at the site.

Inspect the shipping case for signs of damage upon receiving the nephelometer. Carefully unpack the nephelometer and remove it from the shipping case or box.

Feed the hoist rope through the two (2) pulleys on the underside of the precipitation/solar radiation shield (see Figure 4-1), and attach the nephelometer hoist rope hook to the circular hook on top of the nephelometer (see Figure 4-1).

Loosen the four (4) mounting nuts on the top of the nephelometer.

Use the rope to raise the nephelometer to the precipitation/solar radiation shield.

TIE THE ROPE SECURELY TO THE TOWER NEAR THE GROUND, so that the nephelometer is suspended under the mounting bracket of the precipitation/solar radiation shield.

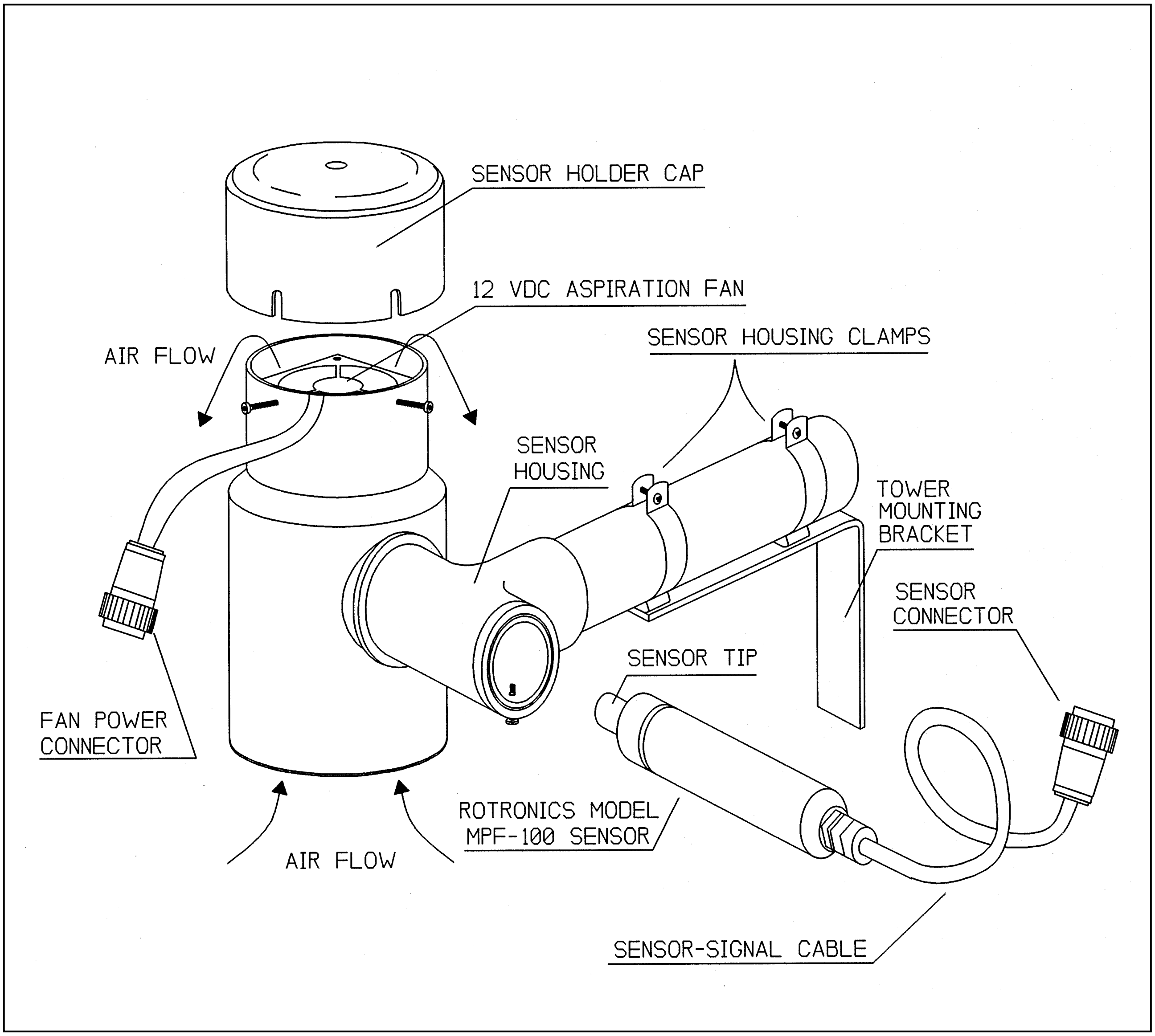


Figure 4-5. Rotronics Air Temperature/Relative Humidity Sensor Component Diagram.

To Disconnect the AT/RH Cable:

- use pliers (channel-lock) to keep ① connection end from AT/RH cable from moving
- use hand (thumb and index finger) to disconnect connection from DCP cable. Rotate counterclockwise

To Connect the AT/RH Cable:

- line up ② connection from DCP cable with ① connection from AT/RH cable
- hand tighten only, rotating ② connection from DCP cable clockwise until secure

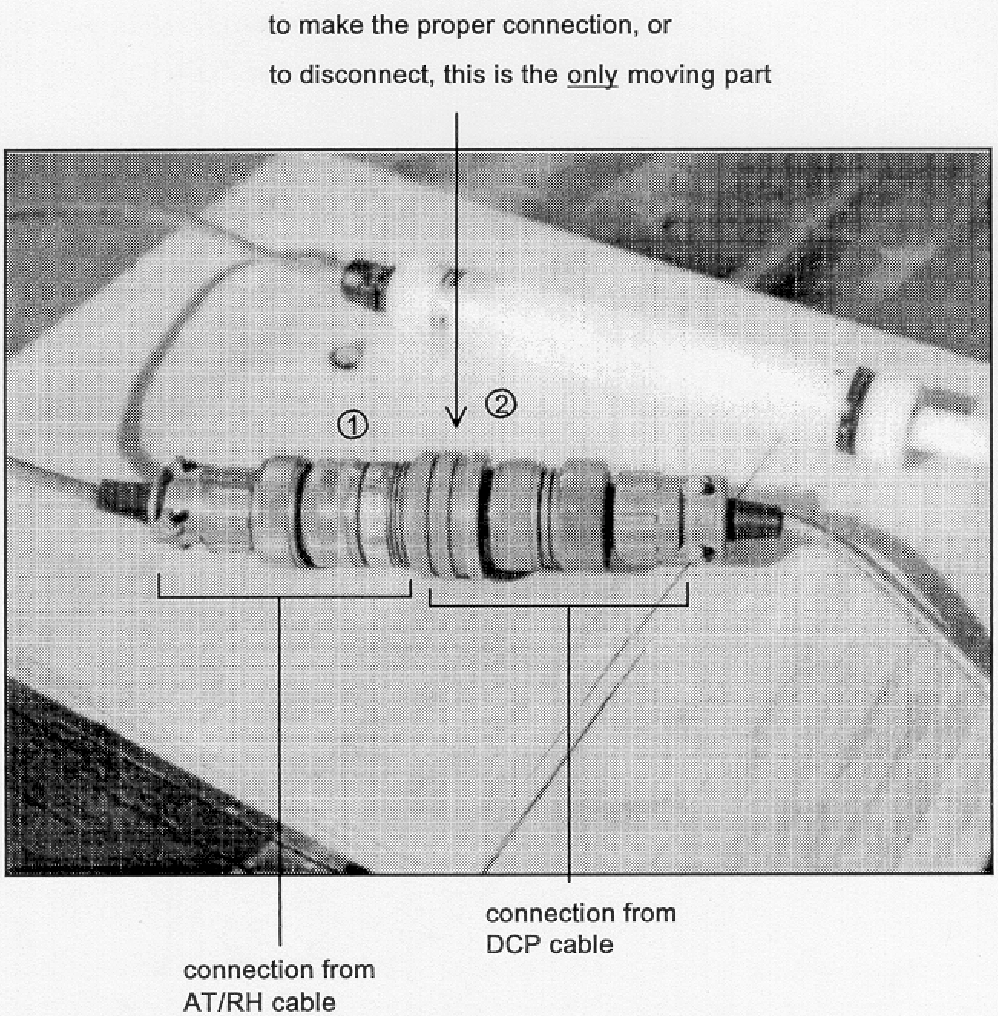


Figure 4-6. AT/RH Sensor/DCP Cable Connection Diagram.

Slide the nephelometer into the slots on the precipitation/solar radiation shield and tighten the nuts on top of the nephelometer.

Remove the hoist rope.

CONNECT — Connect the signal/power cable to the back of the nephelometer and to the data logging and control subsystem. After inspecting for dust and debris within the connectors, use a blower brush to clean the connector, if needed. Wipe a cleaning cloth around the thread inside the connectors if excess dust has collected there.

Connect the span gas hose to the back of the nephelometer.

DOCUMENT — Document installation of the instrument on the operator log sheet (see Figure 4-2).

CALIBRATE — Perform a nephelometer span/zero calibration as described in TI 4200-2000, *Calibration of Optec NGN-2 Nephelometers (IMPROVE Protocol)*.

4.2.2 Installing the Data Logging and Control Subsystem

Follow the procedures below when installing the data logging and control subsystem:

INSTALL — Carefully unpack the enclosure.

Open the enclosure and remove packing material (bubble-wrap) from any components secured for shipping. The following items may require unpacking:

- Campbell datalogger
- Campbell storage module
- Campbell modem
- AC surge protector
- Other loose components

Verify that all components in the enclosure are positioned properly (see Figure 4-4).

Check for loose wiring in the enclosure, especially on the datalogger terminal strips and interface circuit board.

Attach the enclosure to the tower or other mounting support using four (4) bolts or screws.

CONNECT — Connect the following cables to the AC connectors and connector panel on the bottom outside of the enclosure after inspecting for dust and debris within the connectors. Figure 4-7 and Table 4-1 describe the connectors on the subsystem. Use a blower brush to clean the connector if needed. Wipe a cleaning cloth around the thread inside the connectors if excess dust has collected there.

- AC power
- Nephelometer power/signal
- AT/RH sensor with fan power
- Telephone line
- Handar 540 DCP (if used)

Turn on or plug in the main AC power supply to the enclosure.

Program the datalogger and set the time to local standard time and Julian date. (Refer to TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*.

Verify correct operation of the datalogging system (see TI 4100-3100).

4.2.3 Installing the Handar 540 DCP

Any replacement data collection platform (DCP) sent from ARS will be preprogrammed and be set to the "RUN" mode. It will start collecting data as soon as the cables from the data logging and control subsystem are attached. Data will be transmitted after the antenna cable is attached and internal channel selection switches are set to the proper positions. Refer to Figure 4-3, Handar 540 DCP Component Diagram, for the location of the described parts. Follow the steps listed below to install the DCP:

INSTALL — Notify the data coordinator before going into the field to install the DCP. The data coordinator must activate the channel with the satellite service center prior to transmitting.

Attach the DCP to the tower or locate the DCP in the correct position within the shelter.

CONNECT — Connect the trickle charger or solar panel power cable to the correct position on the DCP panel. The cable from the solar panel or AC trickle charger should be connected directly to the connector labeled "solar panel trickle charger."

Connect the antenna to the gold coaxial connector located on the upper right of the input panel.

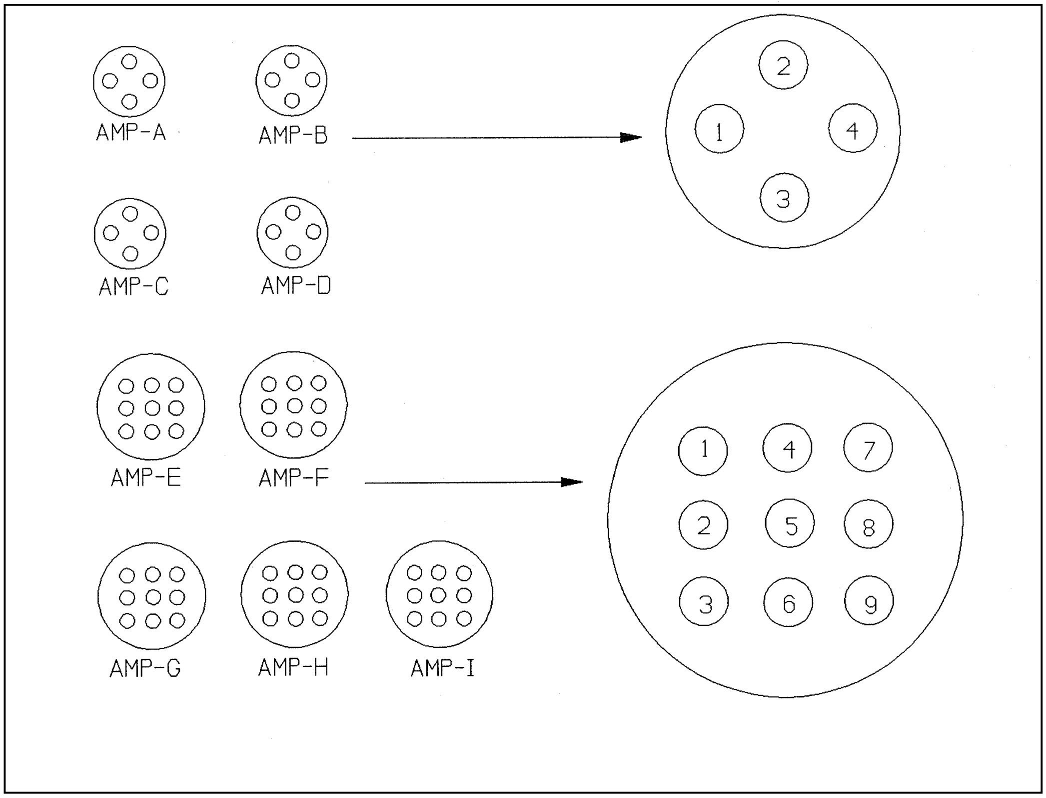


Figure 4-7. Data Logging and Control Subsystem Connector Panel Diagram (Viewed from inside the enclosure).

Table 4-1

Data Logging and Control Subsystem Connector Panel Description

Connector	Function
A	Terminal
B	Not used
C	Telephone line
D	Not used
E	Not used
F	Handar 540 DCP
G	Not used
H	Rotronics AT/RH and fan
I	Nephelometer

Connect the sensor input cable from the data logging and control subsystem to the connector labeled "TRANS". Figure 4-7 and Table 4-1 describe the connectors on the data logging and control subsystem.

Loosen the door clamps with a large, flat-blade screwdriver and open the DCP door.

Change the setting of transmission channel 1 from "900" (3 switches) to the channel requested by ARS. Channels used will be "009" for eastern sites and either "014, 038 or 002" for western sites.

Close the DCP door and re-tighten the clasps.

Check the antenna alignment, elements, and cable.

Store the DCP shipping box, unless it is needed to return a malfunctioning DCP.

DOCUMENT — Document the DCP installation on the operator log sheet.

Notify the data coordinator when the installation is complete.

4.2.4 <u>Installing the Rotronics Air Temperature/Relative Humidity Sensor</u>

The Rotronics AT/RH sensor is installed in the forced-aspirated shield on the tower. Follow the procedures below when installing the AT/RH sensor:

INSTALL — Slide the sensor into the shield and tighten the sensor-securing bolt.

CONNECT — Attach the sensor to the signal cable after inspecting for dust and debris within the two connectors. Use the blower brush to clean the connector if needed. Wipe a cleaning cloth around the thread inside the connector if excess dust has collected there. (See Figures 4-5 and 4-6 for proper connection).

Check that the signal cable is secured to the data logging and control subsystem. Refer to Figure 4-7 and Table 4-1 for data logging and control subsystem connector information.

Check that the aspiration fan power cable is secured to the data logging and control subsystem and that the aspiration fan is operating.

Check that the sensor is operating correctly. Refer to TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*.

DOCUMENT

Document the installation of the sensor on the NGN-2 Nephelometer/Meteorology Log Sheet.

Call ARS to advise the data coordinator of the installation.

4.3 PACKING AND SHIPPING

SHIPPING CASES

Shipping cases or boxes will be sent to the site for the nephelometer, DCP, and data logging and control subsystem. Shipping containers for other equipment or instruments must be found locally (or will be provided by ARS upon request).

SHIPPING

Shipping costs should be charged to the air quality project's COSTSaccount. Other arrangements can be made if:

- UPS shipment is required and cannot be charged to the air quality account.
- There are problems meeting insurance requirements (government use of U.S. Mail).
- An air quality account does not exist.

Call ARS to discuss alternate plans for covering shipping costs.

SHIPPING MISCEL-LANEOUS

Use packing tape to seal the shipping cases. When shipping items in a cardboard box, use nylon filament packing tape to help strengthen the box. If the shipped items are not expected at ARS, or if an explanation on the return of the items would be valuable, enclose it in an envelope within the shipping case or box.

SHIPPING ADDRESS

Mail all items, including correspondence and instruments to:

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525

Telephone: 970/484-7941 or 970/224-9300

Notify ARS when and with which shipper monitoring components were sent, so that the delivery date can be estimated.

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**NEPHELOMETER ANNUAL LABORATORY MAINTENANCE (IMPROVE PROTOCOL)**
TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4100-3400**
DATE	**JUNE 1995**

AUTHORIZATIONS

TITLE	NAME	SIGNATURE
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PROJECT MANAGER	James H. Wagner	
PROGRAM MANAGER	David L. Dietrich	
QA MANAGER	Gloria S. Mercer	
OTHER		

REVISION HISTORY

REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	Add/change order of procedures.	October 1996	

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LIST OF FIGURES

1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes laboratory maintenance procedures for Optec NGN-2 nephelometers operated according to IMPROVE Protocol. The purpose of laboratory maintenance is to assure quality data capture and minimize data loss by:

- Performing and documenting a post-field instrument inspection, functional test, and calibration on each nephelometer when it is returned from a field site.
- Performing and documenting the following nephelometer maintenance procedures:
  - Nephelometer disassembly and cleaning
  - Preventative maintenance
  - Non-standard repairs
- Performing and documenting factory-authorized upgrades

This TI, as referenced from SOP 4100, *Nephelometer Maintenance, (IMPROVE Protocol)*, specifically describes nephelometer maintenance procedures to be performed during annual laboratory servicing of the Optec NGN-2 nephelometer.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Verify that laboratory maintenance is performed according to the required schedule.
- Verify that the Optec NGN-2 Nephelometer Servicing Checklist has been completed following the servicing and that all servicing functions were performed properly.
- Ensure that all instruments are serviced in accordance with the procedures described in this technical instruction.

2.2 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Perform all laboratory servicing and maintenance procedures described in this TI.
- Document all servicing and maintenance work using the Optec NGN-2 Nephelometer Servicing Checklist.

2.3 FIELD SPECIALIST

The field specialist shall provide technical support to the instrument technician in identifying and correcting instrument functional problems.

The data coordinator shall provide the instrument technician with a description of any instrument problems suspected or identified during the time the instrument operated in the field.

3.0 REQUIRED INSTRUMENTATION, TOOLS, EQUIPMENT, AND MATERIALS

Specific instrumentation, tools, equipment, and materials required for nephelometer servicing includes:

- Electronics laboratory instrumentation:
  - Digital voltmeter (4 1/2 digit display)
  - Dual channel oscilloscope (20 mHz bandwidth)
  - Regulated power supply (12 VDC @ 10 amps)
- Optical laboratory equipment instrumentation:
  - Variable transformer base
  - Tungsten illuminator
  - Adapter ring
  - Alignment target
- Specialized nephelometer servicing support equipment:
  - IBM PC-compatible computer terminal (network access to PROCOMM communications software)
  - Support circuit board test fixture
  - Reference temperature sensor
  - Flowmeter
- Cleaning and servicing supplies:
  - Contact cleaner
  - Flux remover
  - Canned air
  - Liquid glass cleaner
  - Kimwipes (low linting tissue)
  - Microfiber optical cleaning cloth

- Ultrasonic cleaner
- Black paint (Krylon, Ultra flat black 1602)
- White paint (Krylon, Glossy White 1501)
- Soft cloth
- Cement glue
- Silicone lubricant
- Water for cleaning cloth

• Hand tools:

- Drill and jigs
- Wire brush
- Small, medium, and large flat-blade screwdriver
- Small and medium adjustable wrench
- Allen wrench set
- Small wire cutter and stripper
- Pliers (standard, needle nose, and long nose)
- Alignment tool (flat-blade tip)
- Contact extraction tool (for Amp Series 1 circular plastic connectors)
- Soldering station

• Servicing forms:

- Optec NGN-2 Nephelometer Servicing Checklist
- *Model NGN-2 Open-Air Integrating Nephelometer Technical Manual for Theory of Operation and Operating Procedures* (Optec, Inc.)

4.0 METHODS

Each nephelometer returned from a field site for annual laboratory maintenance is inspected and tested prior to initiating any servicing procedures that could invalidate the instrument calibration. Post-field inspecting and testing is performed immediately after the instrument is received at ARS. All servicing procedures are documented on the Optec NGN-2 Nephelometer Servicing Checklist (see Figure 4-1). This section contains five (5) major subsections, which are listed on the checklist:

4.1 Initial Inspection and Calibration
4.2 Annual Cleaning and Maintenance
4.3 Non-Standard Repairs
4.4 Operational Verification and Calibration
4.5 Shipping and Documentation

The instrument technician shall complete the following general information on the checklist, prior to performing servicing:

- NGN-2 serial number
- Owner/Network of the instrument
- Date of servicing
- Last operational period of the instrument
- Service technician performing the servicing
- Last site the instrument operated at
- Service type (annual, repair, warranty)

4.1 INITIAL INSPECTION AND CALIBRATION

Initial inspection and calibration of a nephelometer includes the following procedures:

POST-OPERATIONAL CALIBRATION

The post-operational/pre-maintenance calibration documents the condition of the nephelometer before any maintenance is performed. Perform a simple and complete calibration as described in TI 4200-2000, *Calibration of Optec NGN-2 Nephelometers (IMPROVE Protocol)*. Attach the NGN-2 calibration form and the printed calibration results to the checklist.

POST-OPERATIONAL INSPECTION

Inspect the nephelometer exterior, all interior chambers, and the measurement chamber for contamination, dirt, component failures, and other items that affect the operation of the nephelometer. Specifically, the following should be checked:

<u>Exterior</u>

Note any damage to or contamination of the following:

- Mounting studs
- Clean air filter assembly and threaded mounting stud (remove and examine interior)
- Span gas inlet assembly
- Door

OPTEC NGN-2 NEPHELOMETER SERVICING CHECKLIST

NGN-2 Serial Number: ____________________ Owner/Network: ____________________
Date: ___________________________________ Operational Period: ___________________
Service Technician: ________________________ Last Site: ___________________________

Service Type: ☐ Annual ☐ Repair Service ☐ Warranty Service

Completed	See Comments	**Initial Inspection and Calibration:**
☐	☐	Post-operational Calibration (attach NGN-2 Calibration Form)
☐	☐	Post-operational Inspection. Describe the "as returned" condition:

Exterior: ____
____

Interior (electronics and lower chamber): ________________
____

Measurement chamber: _________________________________
____

Comments: ____
____
____

Exterior		**Annual Cleaning and Maintenance:**
☐	☐	Clean outer surfaces
☐	☐	Clean rain detector contacts
☐	☐	Disassemble front, back, and bottom
☐	☐	Exterior (white gloss) paint touch up

Electronics Chamber

☐	☐	Clean electronics chamber
☐	☐	Replace D to A analog output chips
☐	☐	Replace serial communication chips
☐	☐	EPROM upgrade; to EPROM ______________________
☐	☐	Check jumper settings (circle one): **J1**: 5V 10V **J2**: 5V 10V
☐	☐	Upgrade rain sensor sensitivity
☐	☐	Upgrade transient voltage suppressors

Lower Chamber

☐	☐	Clean lower chamber
☐	☐	Replace sample fan
☐	☐	Replace sample fan guard (if corroded)
☐	☐	Upgrade to longer feet
☐	☐	Inspect clean air pump and tubing for moisture and contamination
☐	☐	Upgrade cone light trap
☐	☐	Clean light trap
☐	☐	Replace light trap wick (if needed)

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Figure 4-1. Optec NGN-2 Nephelometer Servicing Checklist.

OPTEC NGN-2 NEPHELOMETER SERVICING CHECKLIST (continued)

Completed   See Comments

Optical Chamber   **Annual Cleaning and Maintenance (continued):**

☐ ☐ Clean optical chamber
☐ ☐ Clean telescope lens
☐ ☐ Clean light detector
☐ ☐ Upgrade aperture ring screwed to manifold
☐ ☐ Interior (flat black) paint touch up
☐ ☐ Replace chamber door drain wicks (if needed)

Lamp Assembly

☐ ☐ Clean lamp assembly
☐ ☐ Inspect lamp housing
☐ ☐ Upgrade lamp housing modifications
☐ ☐ Install new lamp
☐ ☐ Replace chopper motor

Calibration System

☐ ☐ Upgrade span gas valve mounting and connections
☐ ☐ Clean the clean air filter housing
☐ ☐ Upgrade removable clean air filter assembly
☐ ☐ Replace clean air filter
☐ ☐ Upgrade door motor
☐ ☐ Reassemble front, back, and bottom

Optical and Electronic Alignment

☐ ☐ Focus telescope
☐ ☐ Align optics
☐ ☐ Verify chamber temperature sensor
☐ ☐ Test and adjust zero-cross detector timing

Comments: ____
____
____

Non-Standard Repairs:

☐ ☐ ____________________________
☐ ☐ ____________________________
☐ ☐ ____________________________
☐ ☐ ____________________________
☐ ☐ ____________________________
☐ ☐ ____________________________
☐ ☐ ____________________________
☐ ☐ ____________________________

Comments: ____
____
____

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Figure 4-1. (Continued). Optec NGN-2 Nephelometer Servicing Checklist.

OPTEC NGN-2 NEPHELOMETER SERVICING CHECKLIST (continued)

Completed   See Comments

Operational Verification and Calibration:

☐ ☐ Circuit board integrity checked
☐ ☐ Serial output verified
☐ ☐ Analog output verified
☐ ☐ Document user parameter settings:

SN	__________	Auto Test	_______
Run Mode	__________	Total Run Time	_______
Intervals	__________	Low Lamp Limit	_______
Date & Time	__________	Fog Limit	_______
Auto Span	__________	Analog-1 Multiplier	_______
Stored Baud Rate	__________		

☐ ☐ Post-maintenance calibration (attach results)
☐ ☐ 24-hour operational test

Comments: ____
____
____

Shipping and Documentation:

☐ ☐ Instrument return shipped:

Date: ______________________________
Carrier: ______________________________
Type: ______________________________
Weight: ______________________________
Tracking No.: ______________________________

☐ ☐ Service documentation forwarded to ARS Tech. Accounting
☐ ☐ Hard copy of service documentation filed
☐ ☐ Service documentation records entered into database:

Date: ______________________________
Entered by: ______________________________

Comments: ____
____
____

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Figure 4-1. (Continued). Optec NGN-2 Nephelometer Servicing Checklist.

- Door gasket, screen, rain detector
- Feet
- Light trap (remove and examine interior)
- Sample fan and guard
- Lamp tray assembly (wires, lamp holder)

Interior (Electronics chamber)

Note damage to any of the circuit boards, wiring, connectors, or other components, including:

- Support circuit board
- Computer circuit board
- Direct light/temperature sensor circuit board
- Scattered light detector circuit board and housing
- Clean air pump and tubing
- Solenoid
- Span gas valve
- Door motor

Measurement Chamber

Remove the door and measurement chamber side panel. Examine the measurement chamber for the following:

- Dirt and/or insect debris on the walls and floor
- Damage to the aperture ring, baffle, or other components
- Paint peeling from any painted surface
- Evidence of water contamination

Note all inspection findings on the servicing checklist before continuing with system cleaning.

4.2 ANNUAL CLEANING AND MAINTENANCE

Annual cleaning and maintenance of a nephelometer includes the following procedures:

Exterior

CLEAN OUTER SURFACES	Clean the outer surfaces of the nephelometer with a mild cleaner and a soft cloth.
CLEAN RAIN DETECTOR CONTACTS	Clean the rain detector contacts on the door with contact cleaner and a wire brush.
DISASSEMBLE NEPHELOMETER	Disassemble the front, back, and bottom of the nephelometer.
PAINT EXTERIOR	If necessary, paint the exterior with white gloss paint (Krylon, Glossy White 1501).

Electronics Chamber

CLEAN ELECTRONICS CHAMBER	Remove accumulated dust from the electronics chamber with compressed air, a mild cleaner, and a soft cloth. Clean residue from the circuit boards with residue-free canned contact cleaner.
REPLACE D/A CHIPS	Replace the two digital-to-analog (D/A) output chips on the main circuit board. The chips are labeled U20 and U21 and are type AD7248AQ. Verify the new chips are oriented correctly in the sockets.
REPLACE SERIAL COMMUNICATION CHIPSMC1489).	Replace the two serial communication chips on the main circuit board. The chips are labeled U16 (type MC1488) and U17 (type Verify the new chips are oriented correctly in the sockets.
EPROM UPGRADE	The current EPROM version in use at all IMPROVE sites is NEPH1056. Newer versions (including NEPH1071) contain several errors and should not be used. Verify that the replacement EPROM is oriented correctly in the socket.
CHECK JUMPER SETTINGS	Verify the analog output range jumper settings on the computer circuit board. All IMPROVE nephelometers should be set to the 5 volt range for the A1 and A2 channels. The jumper position for the 5 volt range are the middle and lower pins on the jumper header.
UPGRADE RAIN SENSITIVITY SENSOR	The rain sensor sensitivity enhancement includes three modifications to the nephelometer:

- Cement two triangular water diverters to the rain detector on the nephelometer door.
- Replace resistor R9 (787KΩ) on the support circuit board with a 3MΩ resistor.
- Replace resistor R7 (1KΩ) on the support circuit board with a 2KΩ resistor.

UPGRADE TRANSIENT VOLTAGE SUPPRESSORS

Install the transient voltage suppressors on the following connectors:

- Interface circuit board J4-1, J5-6, and J5-12
- Single Board Computer (SBC), J3-2, J3-3, J4-2, and J4-5, ground all suppressors to chassis ground

Lower Chamber

CLEAN LOWER CHAMBER

Clean the lower chamber with compressed air, liquid glass cleaner, and a soft cloth.

REPLACE SAMPLE FAN AND FAN GUARD

Replace the sample fan by removing the four screws securing the fan and fan blade guard. Verify that the polarity of the fan voltage is correct (red wire positive) and that the fan mounted will exhaust air from the inside of the measurement chamber. Replace the fan blade guard if it is corroded or otherwise damaged.

UPGRADE TO LONGER FEET

Longer feet are required when the cone light trap has been installed on the nephelometer. The longer feet replace the existing feet using new longer screws.

INSPECT CLEAN AIR PUMP AND TUBING

Inspect the clean air pump and tubing for moisture and contamination. Replace contaminated tubing.

Connect the pump to a 12 VDC supply and test the input and output using a flowmeter. If the flow is less than 3.5 lpm in either direction, inspect and replace as necessary the intake and exhaust valves and the diaphragm. If there is nothing apparently wrong with those, then replace the pump. If any of the items needed replacement, note that in "non-standard repairs."

UPGRADE CONE LIGHT TRAP

The cone light trap is a simple replacement for the existing factory light trap. The cone light trap consists of two pieces: the base and the bottom. The procedures for replacing the light trap include:

- Remove the two screws securing the existing light trap to the nephelometer.
- Attach the base of the cone light trap to the nephelometer using new shorter screws.
- Screw the bottom of the cone light trap onto the base piece.

CLEAN THE LIGHT TRAP

Clean the light trap with compressed air and a damp cloth.

REPLACE LIGHT TRAP WICK

Replace the light trap wick if it is moldy, damaged, or otherwise contaminated.

Optical Chamber

CLEAN THE OPTICAL CHAMBER	Remove dust accumulation using compressed air and a water-moistened, soft lint-free cloth. Excessive dirt on or paint peeling off of the walls of the optical (measurement) chamber may require repainting.
CLEAN THE TELESCOPE LENS	Clean the telescope lens in the ultrasonic cleaner as follows: • Remove the scattered light detector circuit board from the telescope by loosening the two small Allen screws. Loosen the three large Allen screws and remove the telescope. • Remove the lens from the telescope by loosening the two set screws holding it in place. • Clean the lens for 10 minutes. • Place the lens back on the telescope and tighten the two set screws. • Do not reinstall the telescope at this time.
CLEAN THE DIRECT LIGHT DETECTOR	Clean the direct light detector with an optical cleaning cloth.
UPGRADE THE APERTURE RING SCREWED TO MANIFOLD WALL	The aperture ring in the optical chamber defines the cone of light illuminating the air being measured. The glue securing the aperture ring in existing nephelometers can fail. Secure the aperture ring to the manifold wall as follows: • Remove the manifold wall from the nephelometer. • Place a drill jig over the aperture ring and align holes horizontally. • Drill holes through the ring and wall. • Attach the ring with #2 screws. • Remove the jig.
PAINT INTERIOR	If necessary, paint the measurement chamber walls and baffle with flat black paint.
REPLACE CHAMBER DOOR WICKS	Replace the measurement chamber door drain wicks if they are moldy, damaged, or otherwise contaminated.

Lamp Assembly

CLEAN LAMP ASSEMBLY — Clean the lamp assembly with compressed air and a damp cloth.

INSPECT LAMP HOUSING — Inspect the lamp housing assembly. Repair or replace any broken components or bare wires. Check for loose solder connections.

UPGRADE LAMP HOUSING MODIFICATIONS — The modifications to the lamp housing allow the housing and lamp to be removed from the nephelometer as a unit for easy lamp replacement. The modifications minimize damage to the lamp wires that frequently occurred with the older system. The following procedures describe the lamp housing modifications:

- Drill a 11/16" hole 6" from the bottom and 1 3/8" from the left side of the back.
- Place a water-tight strain relief in this hole.
- Drill a 5/8" hole in the center of the lamp housing plate.
- Place a CONXALL 2-pin waterproof plug in this hole.
- Use two conductor #18 PVC-coated cable from the support board out through the strain relief, then connect a CONXALL waterproof socket on cable.
- Connect two #18 wires to the plug.
- Connect #6 stud crimpon connectors to wires.
- Attach the studs with #3 metric screws to the lamp socket.

INSTALL NEW LAMP — Install a new lamp.

REPLACE CHOPPER MOTOR — Remove the old chopper motor and blade assembly by removing the two screws securing the chopper motor. Remove the blade from the old motor and place on the new motor. Install the new motor and blade assembly and verify that the blade spins freely when it is installed.

Calibration System

UPGRADE SPAN GAS VALVE — To accommodate the large orifice span gas valve, existing fittings and tubing must be modified. Procedures for performing these modifications and installing the large orifice span gas valve are as follows:

- Remove the old valve and external elbow.
- Disconnect all tubing at the tee connector.

- Disconnect tubing from the chamber inlet.
- Cut the tubing removed from the chamber inlet to a length of 1" and reconnect to the chamber inlet.
- Connect one in-line nipple of tee to the tubing on the chamber inlet connection.
- Connect a nylon 90° fitting to the opposite in-line nipple of the tee connector with a 1" length of tubing.
- Cut existing tubing from the zero air pump (inlet) to fit a 90° fitting.
- Attach a 2" length of tubing to the 90° nipple of the tee connector.
- Attach the drill jig to the existing valve mounting hole.
- Drill three 9/64" holes as located by jig.
- Remove the drill jig.
- Drill out the threaded hole with a size Z drill.
- Attach the valve mounting plate to the outside of the nephelometer back wall.
- Attach the 1/4" flare fitting to the 1/8" NPT long nipple. Use PTFE thread-seal tape.
- Attach the 1/4" barb nipple to the valve outlet.
- Attach the valve nipple to the tee connector.
- Place the long nipple through the mounting plate and connect to the valve inlet port.
- Tighten all fittings and make sure the 1/4" flare is facing downward.
- Push the flare fitting flush to the mounting plate and tighten the two set screws.

CLEAN THE CLEAN AIR FILTER ASSEMBLY

Clean the clean air filter assembly with a soft cloth. Relubricate o-rings with silicone lubricant.

UPGRADE THE CLEAN AIR FILTER ASSEMBLY

The removable clean air filter assembly is a simple replacement for the existing single-use clean air filter. Verify that a filter cartridge is installed in the assembly during replacement.

REPLACE CLEAN AIR FILTER — Replace the clean air filter cartridge in the clean air filter assembly.

UPGRADE DOOR MOTOR — The older door motors manufactured by SOHO are no longer available. Upgrading the door motor includes installing a new motor manufactured by Globe, and modifying the mounting plate and interface circuit board. The following procedures describe the door motor upgrade modifications:

- Remove the old door motor and mounting plate.
- Enlarge the mounting plate pilot hole to 1/2 inch.
- Connect new wires approximately 2 1/2 inches long to the motor terminals using red wire on the positive terminal and black wire on the negative terminal. Connect two molex terminals to the opposite ends and replace the terminal housing from the old motor on the new terminals.
- Replace the mounting plate and the door motor back in the nephelometer.
- Remove the interface circuit board and replace R-12 with a 12 Ohm, 10 Watt resistor, and install a 100 Ohm, 1 Watt resistor between the collector and emitter of Q-14.
- Replace the interface circuit board.

REASSEMBLE NEPHELOMETER — Reassemble the front, back, and bottom of the nephelometer.

Optical and Electronic Alignment

FOCUS TELESCOPE — Focus the instrument as follows:

- Place the light source (Tungsten illuminator) in a horizontal position on a variable transformer base, and use an adapter ring to hold the telescope on the light source.
- Place a white card 10 1/2" in front of the telescope lens.
- If the spot projected onto the card is not focused sharply, loosen the two set screws holding the field aperture, and adjust the aperture back and forth to achieve the sharpest image, and tighten the two set screws.

ALIGN OPTICS — Verify the optical alignment is correct as follows:

- To install the telescope, put a small amount of lubricant around the base of the telescope. Insert the telescope in the telescope mount. Tighten the three alignment screws.

- Use the telescope adapter ring to place the light source in the telescope.

- Place the alignment target in the light trap hole in the measurement chamber.

- Verify the location of the alignment light source on the target. Adjust the alignment using the three large Allen screws on the telescope.

- Remove the light source and target. Replace the scattered light detector circuit board.

When proper alignment is obtained, tighten the three alignment screws.

VERIFY CHAMBER TEMPERATURE SENSOR

Verify correct operation of the chamber temperature sensor as follows:

- Connect nephelometer test cable to the nephelometer, the computer serial port (COM1), and to the 13.8 VDC power supply.

- Invoke the PROCOMM communications software on the computer. Set the communications parameters to N81 at 9600 baud.

- Turn the nephelometer power supply "ON." Observe the nephelometer Power-On-Self-Test (POST) information showing the user parameter settings.

- Interrupt the nephelometer by entering **^C** on the computer within three seconds of starting the nephelometer. The nephelometer should respond with a ">" prompt.

- Place a reference temperature sensor in contact with the direct light sensor block.

- Turn on the nephelometer and enter the following commands at the nephelometer ">" prompt: **TEMP-TEST**

- Compare the temperature measured by the nephelometer with the reference measurement. If the measurements differ by more than 0.5°C, adjust the nephelometer temperature potentiometer until they match.

- Replace the removable wall on the optical chamber.

ZERO-CROSS DETECTOR TIMING ADJUSTMENT

Verify correct zero-cross detector timing as follows:

- Set the oscilloscope as follows:

  Channel 1: 5 V/Div DC
  Channel 2: 0.2 V/Div DC
  Sweep rate: 10 ms/Div
  Trigger: External

- Connect the oscilloscope external trigger input (EXT) to the cathode of the zener diode on the direct light/temperature sensor circuit board. Connect the ground to the anode.

- Connect the oscilloscope channel 1 input (CH1) to pin #2 of the A/D converter chip (U15). Pin #2 of the A/D converter indicates the A/D converter status (Busy or Not Busy). During integration of the scattered light signal (14 seconds), 15 conversions are performed and CH1 of the oscilloscope will display a string of 15 pulses (each pulse indicating a sample conversion taking place). During integration of the direct light(1 second), eight(8) conversions are performed and eight(8) pulses are displayed. Connect the CH1 ground to test point #2 (TP2).

- Connect the oscilloscope channel 2 input (CH2) to test point #1 (TP1). Test point #1 is the output of the analog multiplexer which selects the A/D converter input signal (scattered light or direct light). The oscilloscope display of this signal is a full cycle of the photometer output, showing both the lamp "on" and lamp "off" phase of the A/D converter input signal.

- Unscrew and remove the light trap from the light trap mounting ring on the bottom of the nephelometer.

- Insert a "light scattering" material (a crumpled, clean Kimwipe works quite well) into the inside of the light trap mounting ring.

- Turn the nephelometer on and enter the following commands at the nephelometer ">" prompt:

  LAMP-ON 1 TO INTEG WORK, then press the "ENTER" key.

- If the zero-cross detector output is properly aligned, the 15 CH1 pulses (A/D converter status) will be centered in the positive going half-cycle during the lamp "on" phase and in the negative going half-cycle during the lamp "off" phase.

- If the A/D converter status pulses are not centered, adjust the zero-cross phase potentiometer until they are.

4.3 NON-STANDARD REPAIRS

Repairs not covered under Section 4.2, Annual Cleaning and Maintenance, are considered non-standard repairs. Non-standard repairs include, but are not limited to, repair or replacement of the following components:

- Zero air pump
- Circuit board repair
- Optics
- Span gas valve
- Structural components

Note all non-standard repairs on the servicing checklist.

4.4 OPERATIONAL VERIFICATION AND CALIBRATION

Operational verification and calibration is performed after all servicing is complete and includes the following:

CIRCUIT BOARD INTEGRITY — Verify that all circuit boards are secured inside the nephelometer with their mounting screws and that all connectors are in place.

VERIFY SERIAL COMMUNICATIONS — Verify that the nephelometer serial communications function correctly as follows:

- If the ">" prompt appears, serial communications are working correctly.
- If the POST does not appear or if "^C" does not interrupt the nephelometer, check the cable connections and PROCOMM communication settings. If all is in order, replace the serial chips (U16 and U17) on the computer circuit board.

VERIFY ANALOG OUTPUTS — Verify correct operation of the analog outputs as follows:

- Verify that serial communications are working correctly.
- Connect a digital voltmeter to the nephelometer test cable A1 channel wires.
- Enter **1000 D/A-A1**. Measure the A1 voltage. It should be 0.500 VDC on the 5 volt range and 1.000 VDC on the 10 volt range.
- Enter **1000 D/A-A2**. Measure the A2 voltage. It should be 0.500 VDC on the 5 volt range and 1.000 VDC on the 10 volt range.

- If the A1 or A2 output do not work correctly, replace the appropriate chip (U20 or U21) on the computer circuit board.

DOCUMENT USER PARAMETERS — Document the user parameter settings that appear on the computer during the POST on the servicing checklist.

POST MAINTENANCE CALIBRATION — The post maintenance calibration verifies correct operation of the nephelometer prior to shipping. Perform a simple and complete calibration as described in TI 4200-2000, *Calibration of Optec NGN-2 Nephelometers (IMPROVE Protocol)*. Attach the NGN-2 calibration form and the printed calibration results to the servicing checklist.

24-HOUR OPERATIONAL TEST — Run the nephelometer in its normal operational mode for 24 hours to verify correct functioning.

4.5 SHIPPING AND DOCUMENTATION

Nephelometer shipping is detailed in TI 4100-3375, *Replacing and Shipping Nephelometer System Components*. Enter all nephelometer laboratory maintenance documentation, including the servicing checklist and calibration results in the appropriate quality assurance database.

5.0 REFERENCES

Optec, Inc., 1993, Model NGN-2 Open-Air Integrating Nephelometer Technical Manual for Theory of Operation and Operating Procedures, Revision 4, November, Lowell, MI.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**ANNUAL SITE VISITS FOR OPTICAL MONITORING INSTRUMENTATION (IMPROVE PROTOCOL)**
TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4115**
DATE	**MARCH 1994**

AUTHORIZATIONS

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REVISION HISTORY

REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) outlines the general tasks performed during annual routine site visits to optical monitoring sites operated according to IMPROVE Protocol. Annual visits to optical monitoring sites are performed to assure quality data capture and minimize data loss by:

- Replacing all field monitoring instrumentation annually with fully refurbished and calibrated instrumentation.
- Ensuring that instrumentation removed from the field after one year of service is fully refurbished and calibrated.
- Ensuring that field support equipment (shelters, towers, power systems, system wiring, etc.) is in good condition and properly maintained.
- Verifying instrument performance in the field.
- Training site operator(s) in routine operations and system troubleshooting.

Two (2) types of optical monitoring instruments are currently operating in the IMPROVE visibility monitoring network:

- Ambient nephelometers (NGN-2)
- Transmissometers (LPV-2)

General tasks performed during an annual site visit are basically the same for both instruments. Detailed instrument-specific annual site visit procedures referenced by this SOP are as follows:

- TI 4115-3000, *Annual Site Visit Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*
- TI 4115-3005, *Annual Site Visit Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*
- SOP 4700, *Optec NGN-2 Nephelometer Audit Procedures (IMPROVE Protocol)*
- SOP 4710, *Transmissometer Field Audit Procedures*

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Coordinate with the site operator, his/her supervisor, field specialist, instrument technician, and data analyst regarding priority and scheduling of routine servicing trips.

- Coordinate with the field specialist and instrument technician regarding scheduling, preparation, calibrations, and assignment of instrumentation for each optical field site.

- Communicate to the field specialist, data analyst, and site operator any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.

- Provide the Contracting Officer's Technical Representative (COTR) with a list of scheduled site servicing dates, ARS personnel who will visit each site, and names of the primary site contacts. Site operators and their supervisors must be notified either directly or through the COTR at least two weeks prior to a site visit.

- Review site visit documentation with the field specialist, data analyst, and instrument technician.

- Provide the field specialist with calibration numbers for the installation and reference transmissometers.

- Review on-site audit data to confirm correct system operation before the field specialist leaves the site.

2.2 FIELD SPECIALIST

The field specialist shall:

- Coordinate with the site operator, his/her supervisor, project manager, instrument technician, and data analyst regarding priority and scheduling of routine servicing trips.

- Coordinate with the project manager and instrument technician regarding scheduling, preparation, calibrations, and assignment of instrumentation for each nephelometer field site.

- Communicate to the instrument technician, data analyst, and site operator any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.

- Ensure that all instrumentation (and associated calibrations), equipment, materials, and tools are properly prepared and are fully functional.

- Perform all procedures outlined in this TI.

- Make travel and shipping arrangements.

- Follow-up on resolution of any problems encountered on-site that could not be resolved during the site visit.

- Arrange for on-site purchase and delivery of equipment and/or materials that are best obtained locally.

- Hold a training session for site operators during the site visit.

- Review site documentation with the project manager, instrument technician, and data analyst.

2.3 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Coordinate with the site operator, his/her supervisor, field specialist, project manager, and data analyst regarding priority and scheduling of routine servicing trips.

- Coordinate with the field specialist and project manager regarding scheduling, preparation, calibrations, and assignment of instrumentation for each nephelometer field site.

- Perform all servicing, maintenance, modifications, and calibration of instrumentation prior to the site visit.

- Ensure that all instrumentation is in good operating condition prior to shipment.

- Communicate to the field specialist any equipment or instrument modification, or servicing requirements that must be performed on-site.

- Review site visit documentation with the field specialist, data analyst, and project manager.

2.4 DATA ANALYST

The data analyst shall:

- Coordinate with the site operator, his/her supervisor, field specialist, instrument technician, and project manager regarding priority and scheduling of routine servicing trips.

- Communicate to the instrument technician, project manager, and site operator any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.

- Review site documentation with the project manager, field specialists, and instrument technician.

- Communicate to the field specialist during the site visit any problems evident in the collected data.

2.5 SITE OPERATOR

The site operator shall:

- Coordinate with the project manager, field specialist, instrument technician, and data analyst regarding priority and scheduling of routine servicing trips.

- Communicate to the instrument technician, data analyst, and field specialist any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.

- Be available for training during the site visit and arrange to have at least one backup operator also attend the training session.

- Assist the field specialist with the optical system replacement and other tasks that require assistance.

2.6 TECHNICAL ASSISTANT

The technical assistant shall:

- Verify and update the IMPROVE transmissometer inventory using on-site inventory information recorded during the annual visit.

- Prepare transmissometer on-site inventory report after updating the inventory.

3.0 REQUIRED EQUPMENT AND MATERIALS

The following subsections provide summary lists of equipment and materials required to perform routine on-site maintenance and servicing tasks during annual site visits to optical monitoring sites. Other system components or special tools may be required to perform non-routine field maintenance.

3.1 EQUIPMENT AND MATERIALS FOR NEPHELOMETER SITE VISITS

Specific instrumentation, equipment, tools, and materials generally required for a nephelometer annual site visit include the following (see TI 4115-3005 for a detailed list):

- A replacement nephelometer.

- A replacement datalogging and control subsystem.

- A replacement data collection platform (DCP) (if needed).

- A replacement AT/RH sensor.

- A digital voltmeter (DVM).

- An auditing AT/RH sensor.

- A replacement tank of calibration gas, calibration gas regulator, and uninterruptable power supply.
- A standard field service tool kit.
- An HP200LX Palmtop computer with programs required to communicate with and control the NGN-2 nephelometer, Campbell 21X datalogger, and the Blue Earth micro-controller.
- A telephone handset, line simulator, cables, and a cellular telephone for remote sites.
- Documentation cameras.
- A replacement rotameter (flowmeter).
- A replacement Campbell storage module.
- Nephelometer Servicing Site Visit Trip Report (Figure 4-1)
- Optec NGN-2 Nephelometer Field Installation Shipping Checklist (Figure 3-1)
- Post-maintenance nephelometer calibration data
- Miscellaneous site information (maps, contacts, directions, gates, locks, keys, etc.)
- A Site Operator’s Manual containing all applicable technical instructions.
- Optec NGN-2 Technical Manual for Theory of Operation and Operating Procedures
- Log sheets

3.2 EQUPMENT AND MATERIALS FOR TRANSMISSOMETER SITE VISITS

Specific instrumentation, equipment, tools, and materials generally required for a transmissometer annual site visit include the following (see TI 4115-3000for a detailed list):

- A replacement transmissometer with calibrated lamps.
- A reference transmissometer with calibrated lamps.
- A replacement data collection platform (DCP) (if needed).
- A replacement AT/RH sensor.
- A digital voltmeter (DVM).
- An auditing AT/RH sensor.
- Replacement on-site receiver and transmitter DVMs (if needed).

- A replacement Campbell 21X datalogger.
- A standard servicing tool kit.
- A palmtop computer, capable of programming Handar 540A and 570A data collection platforms, with associated cable connectors.
- A calculator.
- Two 2-way radios.
- Documentation cameras.
- Replacement power supplies and surge protectors/suppressors.
- Replacement solar panel regulator(s) (if needed).
- Transmissometer Servicing Site Visit Trip Report (Figure 4-1)
- Optec LPV-2 Transmissometer Field Installation Shipping Checklist (Figure 3-1)
- Receiver and transmitter site transmissometer field audit forms.
- A Site Operator's Manual containing all applicable technical instructions.
- Log sheets.
- Optec LPV-2 Technical Manual for Theory of Operation and Operating Procedures

4.0 METHODS

Optical monitoring instruments at IMPROVE Protocol monitoring sites are removed from the field for laboratory servicing on an annual basis. Spare monitoring systems are installed as replacements for instruments and support equipment removed for laboratory servicing. Field specialists visit sites to perform this changeout of monitoring system components. As a part an annual site visit, a field specialist also performs a number of equipment checks and performance tests that provide information relating to the system's operation during the past 12 months, and verify that the replacement system has a high probability of operating successfully over the next 12 months. To further ensure successful operation and collection of high quality data, a comprehensive site operator training session, which includes a thorough review of routine operations and system troubleshooting procedures, is conducted by the field specialist.

General procedures included in an annual site visit are basically the same for nephelometers and transmissometers. This section outlines the general procedures for each type of instrument and includes two (2) subsections:

4.1 Nephelometer Annual Site Visits
4.2 Transmissometer Annual Site Visits

Detailed descriptions of annual site visit procedures for nephelometers and transmissometers are provided in TI 4115-3000 and TI 4115-3005.

4.1 NEPHELOMETER ANNUAL SITE VISITS

The nephelometer annual site visit includes the following procedures:

- Pre-visit preparation
- Pre-removal system inspection and equipment inventory
- Pre-removal system performance check and nephelometer calibration
- Removal and replacement of nephelometer, datalogging and control subsystem, and AT/RH sensor
- Post-installation system performance check and nephelometer calibration
- Post-installation system inspection and equipment inventory
- On-site training of the site operator
- Post-visit site operations review and inventory verification
- Archiving of all annual site servicing documentation

4.2 TRANSMISSOMETER ANNUAL SITE VISITS

The transmissometer annual site visit includes the following procedures:

- Pre-visit preparation
- Pre-removal system inspection and equipment inventory
- Pre-removal system operations and performance verification
- Removal and replacement of the AT/RH sensor
- Field audit and removal of the on-site transmissometer
- Installation and field audit of the replacement transmissometer
- Post-installation system operations and performance verification
- Post-installation system inspection and equipment inventory
- On-site training of the site operator
- Post-visit site operations review and inventory verification
- Archiving of all annual site servicing documentation

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
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REVISION HISTORY

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LIST OF FIGURES

1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) outlines and describes the procedures involved in performing annual routine site visits to Optec NGN-2 nephelometer sites operated according to IMPROVE Protocol, with the primary purpose of ensuring quality data recovery and minimizing data loss from the nephelometer system. This TI is referenced in standard operating procedure (SOP) 4115, *Annual Site Visits for Optical Monitoring Instrumentation (IMPROVE Protocol)*.

Operational nephelometers, datalogging and control subsystems, and collocated AT/RH sensors undergo annual laboratory maintenance. These systems are replaced by backup operational systems during an annual site visit. In addition to replacement of the monitoring components, sites are maintained to ensure continued safe operation and site operator(s) are fully trained.

The annual routine site visit includes:

- Scheduling the visit.
- Preparing and shipping equipment and instrumentation to the site.
- Documenting initial conditions.
- Verifying system operation (pre-removal).
- Performing clean air (zero) and upscale span calibrations of the existing system.
- Removing the existing nephelometer, datalogging and control subsystem, and AT/RH sensor.
- Installing the replacement nephelometer, datalogging and control subsystem, and AT/RH sensor. The replacement systems are fully serviced, upgraded, and calibrated, at ARS prior to shipment to the site.
- Verifying replacement system operation (post-installation).
- Performing clean air (zero) and upscale span calibrations of the replacement system.
- Inspecting and maintaining all support equipment.
- Updating site inventories.
- Providing operator training.
- Preparing and return shipping of all instruments, tools, etc.
- Documenting all aspects of the site visit.

This TI outlines annual site visit procedures, except audit procedures (refer to SOP 4700, *Optec NGN-2 Nephelometer Audit Procedures (IMPROVE Protocol*).

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Coordinate with the site operator, his/her supervisor, field specialist, instrument technician, and data analyst regarding priority and scheduling of routine servicing trips.

- Coordinate with the field specialist and instrument technician regarding scheduling, preparation, calibrations, and assignment of instrumentation for each nephelometer field site.

- Communicate to the field specialist, data analyst, and site operator any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.

- Provide the Contracting Officer's Technical Representative (COTR) with a list of scheduled site servicing dates, ARS personnel who will visit each site, and names of the primary site contacts. Site operators and their supervisors must be notified either directly or through the COTR at least two weeks prior to a site visit.

- Review site visit documentation with the field specialist, data analyst, and instrument technician.

2.2 FIELD SPECIALIST

The field specialist shall:

- Coordinate with the site operator, his/her supervisor, project manager, instrument technician, and data analyst regarding priority and scheduling of routine servicing trips.

- Coordinate with the project manager and instrument technician regarding scheduling, preparation, calibrations, and assignment of instrumentation for each nephelometer field site.

- Communicate to the instrument technician, data analyst, and site operator any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.

- Ensure that all instrumentation (and associated calibrations), equipment, materials, and tools are properly prepared and are fully functional.

- Perform all procedures outlined in this TI.

- Make travel and shipping arrangements.

- Follow-up on resolution of any problems encountered on-site that could not be resolved during the site visit.

- Arrange for on-site purchase and delivery of equipment and/or materials that are best obtained locally.

- Hold a training session for site operators during the site visit.

- Review site documentation with the project manager, instrument technician, and data analyst.

2.3 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Coordinate with the site operator, his/her supervisor, field specialist, project manager, and data analyst regarding priority and scheduling of routine servicing trips.

- Coordinate with the field specialist and project manager regarding scheduling, preparation, calibrations, and assignment of instrumentation for each nephelometer field site.

- Perform all servicing, maintenance, modifications, and calibration of instrumentation prior to the site visit.

- Ensure that all instrumentation is in good operating condition prior to shipment.

- Communicate to the field specialist any equipment or instrument modification, or servicing requirements that must be performed on-site.

- Review site visit documentation with the field specialist, data analyst, and project manager.

2.4 DATA ANALYST

The data analyst shall:

- Coordinate with the site operator, his/her supervisor, field specialist, instrument technician, and project manager regarding priority and scheduling of routine servicing trips.

- Communicate to the instrument technician, project manager, and site operator any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.

- Review site documentation with the project manager, field specialists, and instrument technician.
- Communicate to the field specialist during the site visit any problems evident in the collected data.

2.5 SITE OPERATOR

The site operator shall:

- Coordinate with the project manager, field specialist, instrument technician, and data analyst regarding priority and scheduling of routine servicing trips.
- Communicate to the instrument technician, data analyst, and field specialist any on-site problems, maintenance needs, supplies, etc., that should be addressed during the site visit.
- Be available for training during the site visit and arrange to have at least one backup operator also attend the training session.
- Assist the field specialist with the nephelometer system replacement and other tasks that require assistance.

3.0 REQUIRED INSTRUMENTATION, TOOLS, EQUIPMENT, AND MATERIALS

All required equipment and materials are listed on a checklist, which the field specialist completes when preparing for a site visit. Figure 3-1 presents the Optec NGN-2 Nephelometer Field Installation Shipping Checklist.

3.1 INSTRUMENTATION

Instrumentation required during a routine site visit includes:

- A replacement nephelometer.
- A replacement datalogging and control subsystem.
- A replacement AT/RH sensor.
- A digital voltmeter (DVM) (supplied by the field specialist).
- An auditing AT/RH sensor.
- A watch set to National Bureau of Standards (NBS) time.
- An RF wattmeter.

OPTEC NGN-2 NEPHELOMETER
FIELD INSTALLATION SHIPPING CHECKLIST

Site: ______________________
Date: ______________________

Packing List #: ______________________
Method of Shipping: ______________________

[√] TO TAKE	[√] WHEN PACKED	ON-SITE EQUIPMENT	QUANTITY	SERIAL #
		Nephelometer		
		AT/RH Sensor		
		Nephelometer Hood		
		Rotameter		
		Rotameter Enclosure		
		6' Refrigerant Hose		
		Telespike Surge Protector		
		Fuse Kit		
		Lamps		
		Clean Air Filters		
		Site Operator's Manual		

SPARE PARTS KIT

		Reset Switch		
		Display		
		AT/RH Fan		
		Green Indicator Light		
		Red Indicator Light		
		Fuse Holder		
		Span Gas Regulator		
		Rotameter		
		6' Refrigerant Hose		
		Storage Module		
		WD40 Lubricant Spray		

AUDIT EQUIPMENT

		Palmtop Computer		
		Terminal Cable and Adapter		
		Tool Kit		
		Telephone Handset		
		AT/RH Audit Kit		

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Figure 3-1. Optec NGN-2 Nephelometer Field Installation Shipping Checklist.

3.2 TOOLS

A complete tool kit is recommended as on-site tasks vary from instrument repair to minor tower and support system repairs or modifications. Non-standard tools often required include:

- A cordless drill with screw bits, drill bit set, and assorted (¾” – 1½”) wood bits.
- A telephone line crimp tool and modular plugs.
- A crimp tool for datalogger box connections, spare pins, sockets, and connectors.

3.3 EQUIPMENT

Equipment required during a routine site visit includes:

- An HP200LX Palmtop computer, capable of programming the NGN-2 nephelometer and Handar 540A/570A data collection platforms with associated cables, connectors, and hardware.
- Software for the palmtop computer:
  - Handar 540A/570A 545 simulator
  - Site-specific data programs for the Campbell 21X datalogger
  - Campbell Scientific PC208 (including SMCOM, TERM, and EDLOG)
  - DATACOMM terminal emulator (built-in the palmtop)
  - Blue Earth micro-controller programs
- A calculator.
- A telephone handset.
- A telephone line simulator and cables.
- A cellular telephone for remote sites.
- Digital camera for documentation.
- A replacement SUVA calibration gas tank (if needed).
- A replacement calibration gas regulator (if needed).
- A replacement UPS (uninterruptable power supply).
- A replacement telephone line surge suppressor for telephone sites (if needed).
- A replacement rotameter (flowmeter).

- A replacement Campbell storage module.

- A standard field servicing kit:

  - Spare components
  - Chips
  - Hardware
  - Fuses
  - Lamps
  - Connectors
  - Standard cables

3.4 MATERIALS

The following documentation forms and information sheets should be taken on each visit:

- Nephelometer Servicing Site Visit Trip Report (Figure 4-1)

- Optec NGN-2 Nephelometer Field Installation Shipping Checklist (Figure 3-1)

- Calibration parameters for the AT/RH sensor (if applicable)

- Post-maintenance nephelometer calibration data

- Miscellaneous site information (maps, contacts, directions, gates, locks, keys, etc.)

The site operator's manual on-site should contain the following for reference:

- TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*

- TI 4100-3350, *NGN-2 Nephelometer Monitoring System Diagrams and Component Descriptions*

- TI 4100-3375, *Replacing and Shipping Nephelometer System Components*

- Optec NGN-2 Technical Manual for Theory of Operation and Operating Procedures

- Log sheets

4.0 METHODS

This section describes annual site visit procedures for nephelometer systems, and includes nine (9) major subsections:

4.1 Pre-Visit Preparation
4.2 General Trip Information
4.3 System Inspection
4.4 Nephelometer Calibration
4.5 System Operation Verification
4.6 Initial Inventory
4.7 Servicing Summary
4.8 Training Procedures and Documentation
4.9 Post-Visit Procedures

4.1 PRE-VISIT PREPARATION

Prior to travel to the site, the following preparations need to be made (for individual responsibilities refer to Sections 2.1 through 2.5):

- Schedule the site visit and notify the COTR.

- Schedule and perform instrument servicing, calibrations, and tests.

- Coordinate with site personnel to arrange for:

  - Site operator training (approximately 2-4 hours)audit).
  - Assistance with replacement of all necessary components (approximately 1-2 hours).
  - Any other assistance needed from on-site personnel.

- Organize all instruments, equipment, tools, and materials.

- Arrange for on-site procurement of equipment, tools, or materials.

- Verify that the replacement nephelometer, datalogging and control subsystem, and AT/RH sensor have received the appropriate testing and/or calibrations.

- Investigate what site-specific problems need to be addressed on-site.

- Ship instruments, equipment, tools, and materials directly to the site or preferably airfreight all items to a major airport near the site to be held for pick-up by the field specialist.

- Arrange travel.

The field specialist should contact the site operators and their supervisor (if involved with the on-site nephelometer system servicing and maintenance) upon arrival at the site. The prearranged schedules for operator training, system replacement, and any other work the field specialist will need assistance with should be confirmed at this time.

The Nephelometer Servicing Site Visit Trip Report, Figure 4-1, must be used to document servicing tasks. This form generally follows the order in which procedures are performed and serves as a checklist for site conditions review, operational verifications and checks, and inventories. Procedures not included on the trip report are included in SOP 4700, *Optec NGN-2 Nephelometer Audit Procedures (IMPROVE Protocol)*.

NEPHELOMETER SERVICING
SITE VISIT TRIP REPORT

Technician: ______________________________ Site: ______________________________

Instrument Number: ________________________ Dates: ____________________________

Site Visit Objectives: ____

____

____

____

TRIP SUMMARY

Day/Date:	Actions:
________	______________________________________
________	______________________________________
________	______________________________________
________	______________________________________
________	______________________________________
________	______________________________________
________	______________________________________
________	______________________________________
________	______________________________________
________	______________________________________
________	______________________________________
________	______________________________________
________	______________________________________
________	______________________________________
________	______________________________________
________	______________________________________
________	______________________________________

Comments:

____

____

____

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Figure 4-1. Nephelometer Servicing Site Visit Trip Report.

NEPHELOMETER STATION – SYSTEM INSPECTION I

☐ Pre-removal ☐ Post-installation ☐ Internal audit

Support Tower and Structural Components

Physical condition: ______________________________

Condition of guy wires: ______________________________

Condition of the span gas hoses: ______________________________

Condition of the span gas enclosure: ______________________________

Nephelometer Support Hanger

Physical condition of hanger: ______________________________

Attachment of hanger to tower: ______________________________

Nephelometer

Physical condition of nephelometer: ______________________________

Condition of sample inlet screen: ______________________________

Condition of nephelometer signal and power cable: ______________________________

Condition of light trap and clean air filter: ______________________________

Does the instrument appear to be functioning correctly? ______________________________

Document serial counts on *6 locations 5 and 6, and analog counts on *6 locations 4 and 7: ______________

____

Document current lamp value (*6 17) location: ______________________________

Datalogging and Control Subsystem

Physical condition of the system exterior: ______________________________

Condition of ventilation screen: ______________________________

Padlock type, manufacturer, ID, and number: ______________________________

Condition of the support system interior: ______________________________

Condition of the inlet ventilation screen: ______________________________

Condition of the wiring: ______________________________

21X datalogger program version currently installed: ______________________________

Storage module currently installed: ______________________________

Date and time on the 21X datalogger (mm/dd/yy and Julian): ______________________________

Record the concurrent NBS time: ______________________________

***** Change 21X to current time (on final inspection) *****

Condition of the interface circuit board and Blue Earth: ______________________________

Blue Earth indicator LEDs? Red: ON OFF Yellow: ON OFF Green: ON OFF

Front panel LCD display: ON OFF Display: ______________ 21X *6 11 location: __________

Figure 4-1. (Continued). Nephelometer Servicing Site Visit Trip Report.

NEPHELOMETER STATION – SYSTEM INSPECTION II

Power System

Are AC and DC indicator lamps operational? ____________________ Fuses OK? ____________________

DC power supply (VDC): ____

Condition of the AC power line and plug on the enclosure: ________________________________

Condition of the AC wiring inside the enclosure: ____________________________________

Rotronics AT/RH Sensor

***** Attach AT/RH Audit Form *****

Telephone System

Communication possible with Campbell modem?	YES	NO
Communication possible with Campbell 21X?	YES	NO

Additional Maintenance Performed

Document any additional maintenance performed:

____

____

____

____

____

____

____

Figure 4-1. (Continued). Nephelometer Servicing Site Visit Trip Report.

NEPHELOMETER STATION – SYSTEM INSPECTION III

☐ Pre-removal ☐ Post-installation

Nephelometer Manual Calibration

Record the log file name: ______________________

Weight of the span gas container: ______________________

Condition of the span gas hoses: ______________________

Condition of the span gas enclosure: ______________________

POST Information

ROM version: ______________________

Serial number: ______________________

Run mode: ______________________

Clean air intervals (INTERVALS): ______________________

Date and time: ______________________

Automatic span flag (AUTO SPAN): ______________________

Store start-up baud rate (STORED BAUD RATE): ______________________

Automatic test flag (AUTO TEST): ______________________

Total run time: ______________________

Memory checks: CSUM: ______________ ROMTOP: ______________

POST Mechanical Functions

Door: OPEN CLOSED Fan: ON OFF Pump: ON OFF

Lamp: ON OFF Solenoid: ON OFF Valve: ON OFF

Average clean air calibration: ______________ Average span gas calibration: ______________

Automatic Nephelometer Calibration

Automatic clean air zero serial (*6 12): ______________________

Automatic span serial (*6 13): ______________________

Automatic clean air zero serial output from computer: ______________________

Automatic span serial output from computer: ______________________

System Operational Verification

System operational:	YES	NO
Communications verified:	YES	NO
Operator training completed:	YES	NO
Maintenance performed:	YES	NO
Operator's manual complete and current:	YES	NO

Figure 4-1. (Continued). Nephelometer Servicing Site Visit Trip Report.

NEPHELOMETER STATION – SITE INVENTORY

☐ Pre-removal ☐ Post-installation

	Pre-removal Manufacturer	Pre-removal Model #	Pre-removal Serial #	Post-installation Manufacturer	Post-installation Model #	Post-installation Serial #
Antenna						
AT/RH Sensor						
AT/RH Shield						
Datalogger						
Modem						
Nephelometer						
Power Supply						
Blue Earth						
Storage Module						
UPS						
Tower						
Precip/Solar Rad. Shield						
Logging/Control Subsystem						
Span Gas Enclosure						
Span Gas Regulator						
Rotameter						
Nephelometer Hood						
Cellular Telephone						
Cellular Phone Antenna						
Other:______________						
Other: ______________						

Spare parts on site: ____

____

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Figure 4-1. (Continued). Nephelometer Servicing Site Visit Trip Report.

NEPHELOMETER STATION – SERVICING SUMMARY

Pre-removal condition documented?	YES	NO
Pre-removal system operation checked?	YES	NO
Pre-removal site inventory completed?	YES	NO
Pre-removal nephelometer calibration completed?	YES	NO

Replace existing nephelometer? YES NO

Comment: ______________________________

____

____

Replace existing logging and control subsystem? YES NO

Comment: ______________________________

____

____

Replace existing AT/RH? YES NO

Comment: ______________________________

____

____

Other replacement? YES NO

Comment: ______________________________

____

____

Post-installation conditions documented?	YES	NO
Post-installation system operation checked?	YES	NO
Post-installation site inventory completed?	YES	NO
Post-installation nephelometer calibration completed?	YES	NO
Site operator(s) trained?	YES	NO

Comment: ______________________________

____

____

____

____

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Figure 4-1. (Continued). Nephelometer Servicing Site Visit Trip Report.

4.2 GENERAL TRIP INFORMATION

Refer to Figure 4-1, page 1 for the following:

SITE	Use either the full location name or the four-letter site abbreviation.
DATES	Record the calendar date duration of the entire servicing trip, including travel.
TECHNICIAN	Use the full name or the first initial and last name.
INSTRUMENT NUMBER	Record the Optec instrument number.
SITE VISIT OBJECTIVES	List the primary objectives of the site visit, especially any that are not standard for site visits.
TRIP SUMMARY	List the major actions taken for each day, including travel and locations. Any general comments pertaining to the trip should be noted in the comments section.

4.3 SYSTEM INSPECTION

The same information must be collected for the pre-removal and post-installation system configurations. Document the following (refer to Figure 4-1, page 2):

SUPPORT TOWER AND STRUCTURAL COMPONENTS	Note the physical condition of the support tower and condition of the guy wires (tension, attachment to tower, stakes, etc.). Note the condition of the span gas hoses (cracks, discoloration, etc.) and the general condition of the span gas enclosure.
SUPPORT HANGER	Note the general physical condition of the support hanger including the attachment of the hanger to the tower.
NEPHELOMETER	Inspect the nephelometer for any physical damage and for dirt or debris on the inlet screen and exhaust screen. Check the condition of the signal and power cables as well as the connectors. Observe the operation of the nephelometer and note any deviations from normal operation. Remove the light trap and clean air filter and note the condition of each. Record the current lamp value from the *6 17 storage location on the 21X micrologger. Record the current ambient readings for both serial and analog outputs and verify that these values seem reasonable for the existing conditions.

DATALOGGING AND CONTROL SUBSYSTEM	Note the physical condition of the datalogging and control subsystem exterior, note the type of padlock used, the condition of the support system interior, the condition of the inlet ventilation screen, and all wiring. Verify that the storage module is correctly installed. Record the current Campbell 21X micrologger program used and the current logger year, Julian date, and time. Record the concurrent NBS time. Document the physical condition of the interface circuit board regarding the signs of corrosion, dirt, loose connections, etc. Note the current state of the Blue Earth interface by observing the colored LEDs (RED always illuminated when powered, YELLOW flashes when the nephelometer outputs on the serial line, GREEN may flash intermittently but can be ignored). Observe the front panel LCD display and compare it to the 21X *6 11 location (b_{scat} or problem code).

Refer to Figure 4-1, page 3 for the following information:

POWER SYSTEM	Note if the AC and DC lights are operational. Record the DC power supply output voltage. Inspect all power wiring inside and outside of the enclosure.
ROTRONICS AT/RH SENSOR	Refer to TI 3750-6116, *Rotronics MP-100F or MP-101A AT/RH Sensor Audit Procedures (IMPROVE Protocol*) for checking the operation of this sensor.
TELEPHONE SYSTEM	The telephone line is tested by using a handset and calling out. ARS verifies the telephone line and modem by calling into the site.
ADDITIONAL MAINTENANCE PERFORMED	Fully document any additional maintenance required or inconsistencies noted.

4.4 NEPHELOMETER CALIBRATION

Calibration of the existing and replacement nephelometer systems must be performed. The procedures for the pre-removal and post-installation calibrations are identical (refer to Figure 4-1, page 4):

MANUAL CALIBRATION	Attach a palmtop computer to the RS-232 serial port on the support system. Run DATACOMM at 9600 baud and open a log file. Record the log file name on the documentation form. Note the type of span gas used and the approximate weight of the span gas tank to determine how much span gas remains

POST INFORMATION

Record the ROM version used, serial number, and run mode. Record the clean air intervals and date and time. Record the automatic span flag, stored baud rate, and auto test flag. Finally, record the total run time, and memory checks.

POST MECHANICAL FUNCTIONS

Document if the door is open or closed and whether the fan, pump, lamp, solenoid, and valve are on or off. Record the average clean air and span gas calibrations performed.

AUTOMATIC NEPHELOMETER CALIBRATION

Attach the tubing that connects the nephelometer, regulator, and span gas tank. Adjust the tank output pressure to 6-10 psi. Initiate the automatic zero/span sequence by depressing the **RED** button on the logger box front panel for approximately five seconds. Record the POST parameters that appear on the computer screen following power up. The nephelometer will now begin a self test of mechanical functions. Note the functions on the documentation form.

Change DATACOMM to 1200 baud and record the automatic one-minute ambient reading. Following this one-minute reading, the nephelometer will automatically proceed with a 20-minute upscale span calibration followed by a 15-minute zero. Document the 21X *6 locations 12 and 13 (serial zero and span) as well as the zero and span values on the computer.

Leave the DATACOMM log file open and change the baud rate to 9600. Reset the nephelometer and interrupt its operation by entering **CONTROL-C**. Perform a manual calibration by entering nephelometer commands manually. These commands can be found in the Optec technical manual. The log file will record one-minute updates from the nephelometer allowing for a more detailed look at the calibration as it occurs. Several manual calibrations should be performed until the field specialist is satisfied with the repeatability of the calibrations. Close the log file when calibrations are completed. Reset the nephelometer by entering the command **RUN** to allow for normal operation. Print the log file and attach it to the site visit documentation form upon return to ARS.

4.5 SYSTEM OPERATION VERIFICATION

Prior to leaving the site, the field specialist must operationally verify that all systems are fully operational and the operator(s) are fully trained. The field specialist must verify that the Site Operator’s Manual is up-to-date and complete, and that the operator has all necessary monitoring supplies. The field specialist must also verify that ARS is able to automatically collect the data and communicate with the nephelometer system. All communication problems that are serviceable by the field specialist must be resolved before the field specialist ends the site visit.

4.6 INITIAL INVENTORY

Refer to Figure 4-1, page 5. Inventory all items at the nephelometer site according to the inventory list on the servicing form. Also note any additional items on-site that do not appear on the inventory list.

4.7 SERVICING SUMMARY

The site servicing summary page provides a quick reference to tasks performed and problems noted. The page includes comment lines for any necessary explanations. Additional supplemental information, photographs, etc. can be attached to the page (refer to Figure 4-1, page 6).

4.8 TRAINING PROCEDURES AND DOCUMENTATION

Scheduling of the operator training session should occur with the scheduling of the annual site visit. Typically, the training session is scheduled toward the end of the site visit.

All site operators and backup operators should attend the training session, along with the site monitoring manager, if possible. When initially contacting site personnel, confirm that on-site copies of the Site Operator's Manual (refer to Section 3.4) are on hand.

The Site Operator's Manual is the basis for operator training and should be reviewed by operators unfamiliar with the nephelometer system prior to the training session. Approximately 2-4 hours should be allotted for the training session. If time constraints, weather, site accessibility, etc. make training difficult or infeasible, training can be done at another location using system TIs and operator log sheets.

Training topics include:

- Purpose of the monitoring program and the role of Air Resource Specialists, Inc.
- Theory of nephelometer system operation.
- Detailed procedures to be performed during each site visit by the operator.
- Troubleshooting and emergency maintenance procedures.

4.9 POST-VISIT PROCEDURES

The following post-visit procedures must be completed within one (1) week following the field specialists' return:

- Site visit review
- Archiving site visit documentation

4.9.1 Site Visit Review

The field specialist will meet with the project manager, data analyst, and instrument technician to review all annual site servicing documentation. Items to be discussed in this review include:

- On-site equipment or operations problems identified.
- Site operator evaluation.
- Site-related routine servicing requirements.
- Observed factors that could influence nephelometer readings.
- Operations-related requests from the site operator or other on-site personnel.
- Miscellaneous follow-up needs.

4.9.2 Archiving Site Visit Documentation

Upon completion of the site visit review, the data analyst archives all annual site servicing documentation. This documentation is filed in site-specific operations notebooks located in the ARS Data Collection Center. Specific annual site visit documentation archived includes:

- Nephelometer Servicing Site Visit Trip Report
- Field Installation Shipping Checklist

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**CALIBRATION OF OPTICAL MONITORING SYSTEMS (IMPROVE PROTOCOL)**
TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4200**
DATE	**JULY 1993**

AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
ORIGINATOR	D. Scott Cismoski	
PROJECT MANAGER	James H. Wagner	
PROGRAM MANAGER	David L. Dietrich	
QA MANAGER	Gloria S. Mercer	
OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	Added responsibilities/equipment/methods.	October 1996	

TABLE OF CONTENTS

1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) outlines the steps for calibration of optical monitoring instruments operated according to IMPROVE Protocol. Optical monitoring instruments are calibrated periodically to verify an instrument's performance, assure quality data capture, and minimize data loss by measuring an instrument's output in response to well-defined and controlled operating conditions.

The two types of optical monitoring instruments currently operating in the IMPROVE visibility monitoring network are ambient nephelometers and transmissometers. Calibration of ambient nephelometers is required under any of the following circumstances:

- Upon acceptance testing of a new instrument.
- Upon installation in the field.
- Prior to any corrective action, service, or maintenance to any portion of the instrument that would change the instrument's response to specified input conditions.
- At weekly intervals.

Calibration of transmissometers is required under the following circumstances:

- Upon acceptance testing of a new instrument.
- Prior to installation in the field.
- Immediately following removal of the instrument from the field.
- Following any corrective action, servicing, or maintenance that could affect the instrument's operational performance.

Nephelometer and transmissometer calibration results are used to:

- Convert raw measurement values to appropriate engineering units.
- Evaluate the instrument's performance and estimate the precision and accuracy of the instrument for specific operational periods.

The following technical instructions (TIs) provide detailed information regarding specific calibration procedures:

- TI 4200-2000 *Calibration of Optec NGN-2 Nephelometers (IMPROVE Protocol)*
- TI 4200-2100 *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*
- TI 4200-2110 *Transmissometer Lamp Preparation (Burn-in) Procedures*

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Verify that nephelometer calibrations are performed as required.
- Schedule transmissometer calibrations.
- Review all calibration results with the field specialist.
- Identify inconsistencies in calibration results and initiate corrective action as required.
- Review and approve all changes to calibration procedures.
- Review transmissometer lamp inventory and status records to ensure a sufficient number of burned-in lamps are available.
- Approve purchase orders for new lamps.

2.2 FIELD SPECIALIST

The field specialist shall:

- Perform all required field calibrations.
- Document calibration results on the appropriate form.
- Review all calibration results with the project manager.
- Identify inconsistencies in calibration results and initiate corrective action as required.
- Enter calibration results in the site-specific Quality Assurance Database.

2.3 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Perform a nephelometer calibration during acceptance testing and laboratory maintenance.
- Maintain a printout of nephelometer calibration results.
- Enter the calibration results in the site-specific Quality Assurance Database.
- Prepare lamps for transmissometer calibration.
- Measure pre-calibration transmissometer lamp voltages.
- Assist the field specialist in analyzing inconsistencies in calibration results.

- Prepare purchase orders for new lamps.
- Perform lamp burn-in procedures.
- Maintain the lamp inventory and status records.
- Coordinate with Optec, Inc. for replacement of lamps.

2.4 SITE OPERATOR

The site operator shall:

- Perform a nephelometer calibration every week.
- Record the results of the nephelometer calibration on the NGN-2 Nephelometer/Meteorology Log Sheet.

3.0 REQUIRED EQUIPMENT AND MATERIALS

3.1 NEPHELOMETER CALIBRATION

Required equipment and materials to calibrate nephelometer systems include:

- Calibration span gas
- A pressure regulator and adjustable flowmeter
- Calibration gas hoses and fittings
- HP200LX palmtop computer with DATACOMM software
- NEPHCOM.DCF communication configuration file
- Site maintenance forms
- Calibration forms
- TI 4200-2000, *Calibration of Optec NGN-2 Nephelometers (IMPROVE Protocol)*
- TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*

3.2 TRANSMISSOMETER CALIBRATION

Prior to calibrating a transmissometer, the lamps to be used with a specific instrument must be burned-in, to stabilize the lamp's filament position and light output. Required equipment and materials for burn-in includes:

- A supply of lamps
- Lamp ID labels

- Lamp burn-in fixture
- Power supply (13.8 VDC @ 25 amps)
- Documentation forms
- KimWipe tissues
- TI 4200-2110, *Transmissometer Lamp Preparation (Burn-in) Procedures*

Calibration of LPV-2 transmissometers is performed at the Fort Collins Transmissometer Test Facility. Equipment and materials required at the test facility include:

- Tracking transmissometer (LPV-2 transmissometer installed to monitor light transmission measurements over a path parallel and adjacent to the calibration path)
- Tracking nephelometer (NGN-2 nephelometer installed to monitor ambient scattering measurements adjacent to the calibration path)
- Campbell 21X datalogger and solid state storage modules
- Serial printer
- Digital voltmeter (4 1/2 digit)
- Neutral Density Filters (NDFs)
- Assorted calibration apertures
- Power supplies (12 volts DC)
- Cleaning supplies (for windows and transmissometer optics)
- Calibration documentation forms
- TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*

Analysis and review of transmissometer calibration data requires the following:

- IBM-compatible 386/486 computer system with VGA and 80 megabyte hard disk
- Campbell Scientific datalogger support software
- ARS calibration support software

4.0 METHODS

This section includes two (2) major subsections:

4.1 Nephelometer Calibrations
4.2 Transmissometer Calibrations

4.1 NEPHELOMETER CALIBRATIONS

Nephelometer calibration includes performing a clean air zero calibration and a span calibration. Calibration may be simple or complete:

- Simple calibration: A single zero and a single span value generally obtained by the site operator during routine servicing.

- Complete calibration: A series of zero and span values generally obtained during acceptance testing, installation, removal, laboratory servicing, or audit of the nephelometer by the field specialist or instrument technician.

4.1.1 Simple Calibration

Simple calibration of NGN-2 nephelometers occurs during any of the following checks:

- Site operator initiated zero and span checks performed weekly

- Remote, telephone modem initiated zero and span checks

- Field specialist initiated zero and span checks

Simple calibration of NGN-2 nephelometers includes:

- Clean air zero consisting of the average of 10 one-minute readings of particle-free air.

- Span consisting of the average of 10 one-minute readings of a span gas with known scattering properties.

The results of a simple calibration must be recorded on the appropriate documentation form and entered into the site-specific Quality Assurance Database.

4.1.2 Complete Calibration

Complete calibration of NGN-2 nephelometers are generally performed by the field specialist or instrument technician during servicing in the field or in the laboratory. Complete calibrations include:

- Twenty (20) 1-minute clean air zero readings

- Twenty (20) 1-minute span readings

- Recording of ambient temperature, relative humidity, and barometric pressure

The results of a complete calibration must be recorded on the appropriate calibration form and entered into the site-specific Quality Assurance Database.

4.1.3 Instrument Adjustment

Nephelometers must not be adjusted during calibration. Unadjusted calibration values are required for evaluating the performance and estimating the precision and accuracy of nephelometers. If the nephelometer cannot be calibrated, refer to the appropriate troubleshooting standard operating procedure and technical instruction.

4.2 TRANSMISSOMETER CALIBRATIONS

Transmissometer calibration includes pre-calibration preparation of lamps and the actual transmissometer calibration.

4.2.1 Lamp Preparation

Preparation of lamps prior to transmissometer calibration includes:

- Purchasing and visually inspecting lamps upon receipt
- Burning-in the lamps
- Visually inspecting burned-in lamps
- Documenting lamp voltage measurements of burn-in

4.2.2 Transmissometer Calibration

Transmissometer calibration includes pre-field and post-field calibration of an operational instrument, calibration of the audit instrument, and measuring window transmittances, including:

- Uniformity test of transmissometer receiver detector
- Calibration of transmissometer with the appropriate number of lamps for the defined operating period and sample frequency. Ten (10) lamps are calibrated for annual service intervals for instruments operating according to IMPROVE protocols.
- Measuring window transmittances
- Processing preliminary calibration data
- Documenting calibration configuration, weather and visibility conditions, and lamp voltage measurements on the calibration form
- Quality assurance review of calibration data
- Entry of calibration data in to the Transmissometer Calibration Database
- Calculation of site-specific calibration numbers for each lamp
- Maintenance of calibration documentation

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**CALIBRATION OF OPTEC NGN-2 NEPHELOMETERS (IMPROVE PROTOCOL)**
TYPE	**TECHNICAL INSTRUCTION**
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AUTHORIZATIONS

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OTHER		

REVISION HISTORY

REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	Up-scale calibration using upgraded valve	March 1995	
2.0	Modify for use with palmtop computer	October 1996	

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the calibration procedures for Optec NGN-2 nephelometers operated according to IMPROVE Protocol. The purpose of nephelometer calibration is to assure quality data capture and minimize data loss by:

- Performing simple calibrations every week.
- Performing simple and complete calibrations during acceptance testing, installation, removal, and annual site visits.
- Performing simple and complete calibrations during laboratory testing.

The calibration of Optec NGN-2 nephelometers includes:

- Performing a zero calibration using the nephelometer's internal air filtration system.
- Performing a span calibration using a span gas with known scattering properties, usually SUVA-134a.
- Documenting calibration results.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Verify that simple calibrations are performed by the site operator according to the required schedule, and during:
  - Acceptance testing of a new instrument
  - Installation or removal of a nephelometer by ARS staff
  - Laboratory maintenance
  - Annual or audit site visits
- Verify that complete calibrations are performed during:
  - Acceptance testing of a new instrument
  - Installation or removal of a nephelometer by ARS staff
  - Laboratory maintenance
  - Annual or audit site visits

2.2 FIELD SPECIALIST

The field specialist shall:

- Perform a simple calibration and a complete calibration during any site visit.
- Document the results of both calibrations on the annual site visit documentation form.
- Enter the calibration results in the site-specific Quality Assurance Database.

2.3 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Perform a simple calibration and a complete calibration during acceptance testing and laboratory maintenance.
- Maintain a printout of the results of both calibrations.
- Enter the calibration results in the site-specific Quality Assurance Database.

2.4 SITE OPERATOR

The site operator shall:

- Perform a simple calibration every week.
- Record the results of the simple calibration on the NGN-2 Nephelometer/Meteorology Log Sheet.

3.0 REQUIRED EQUIPMENT AND MATERIALS

A span gas calibration system, which includes the following materials, is required for all calibrations:

- Calibration span gas, (typically a 30 lb. non-refillable tank of DuPont SUVA-134a refrigerant)
- A pressure regulator capable of providing tight regulation at low pressure (2 psi) and an adjustable flowmeter compatible and calibrated for use with the span gas are required for providing optimum span gas supply to the NGN-2 nephelometer. (Suggested regulator - Air Products MN E11-N510B. A suggested flowmeter (rotameter) is the Cole Parmer MN N014-96ST).
- Calibration gas hoses and fittings to connect the tank, regulator, rotameter, and nephelometer (see Figure 3-1). The hoses must be compatible with SUVA-134a.

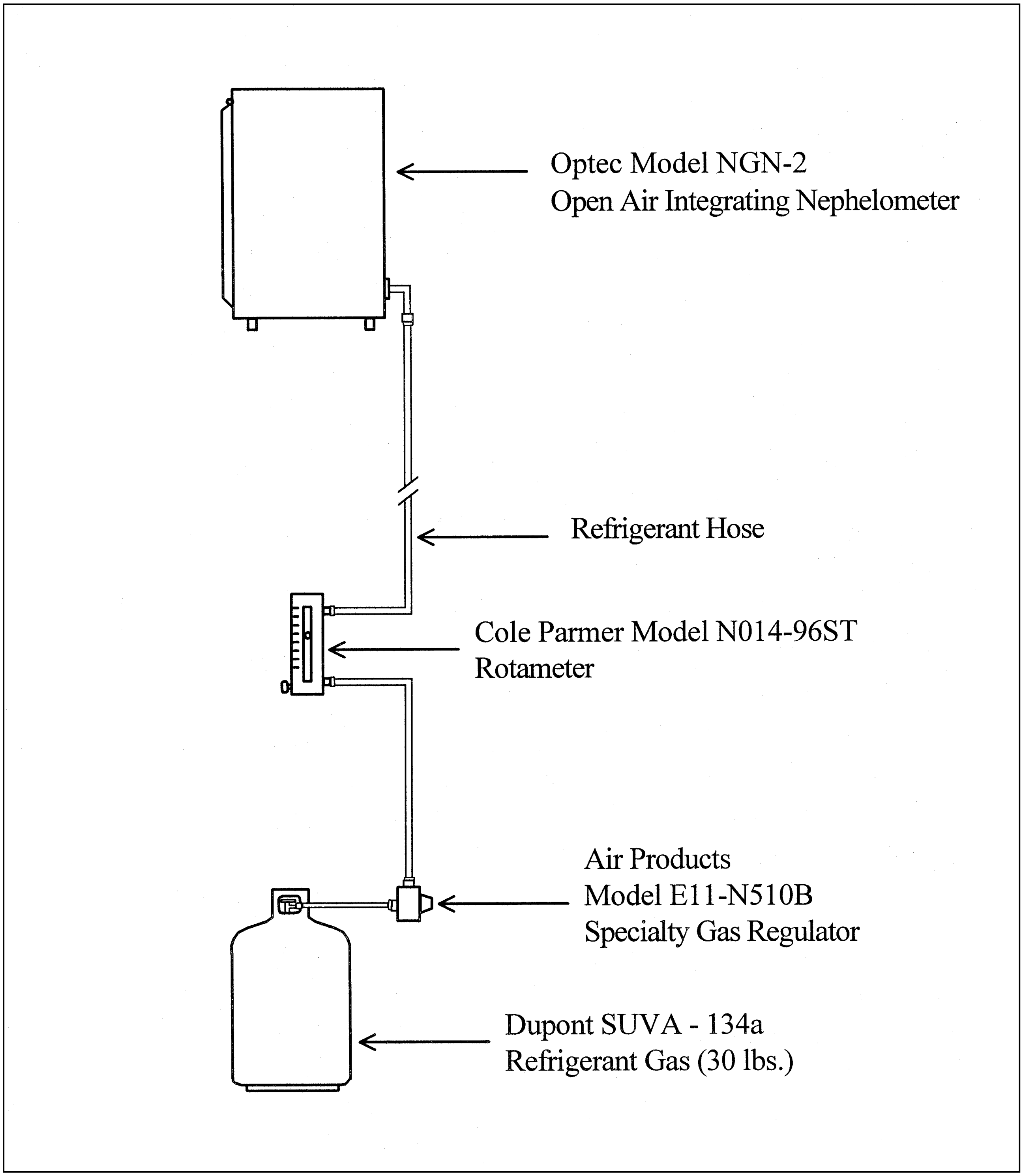

Figure 3-1. Manual Span Gas Calibration/Audit Configuration
for the Optec NGN-2 Nephelometer.

The following additional materials are required to perform a simple calibration:

- TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*
- NGN-2 Nephelometer/Meteorology Log Sheet (site operator only)
- NGN-2 Nephelometer Annual Site Visit Documentation Form (field specialist only)

The following additional equipment and materials are required to perform a complete calibration:

- HP200LX palmtop computer with DATACOMM software
- NEPHCOM.DCF communications configuration file
- Computer-to-nephelometer support system interface cable

4.0 METHODS

The two methods of calibrating Optec NGN-2 nephelometers are the simple calibration and the complete calibration. Simple calibrations are initiated by site operators and field specialists to check the operation of the nephelometer system. Complete calibrations are performed by the field specialist or instrument technician during installations, removals, and laboratory testing. These methods are discussed in the following two (2) major subsections:

4.1 Simple Calibration
4.2 Complete Calibration

4.1 SIMPLE CALIBRATION

Simple calibration of NGN-2 nephelometers occurs during any of the following checks:

- Site operator initiated zero and span checks
- Remote, telephone modem initiated zero and span checks
- Field specialist initiated zero and span checks

Simple calibration of NGN-2 nephelometers includes:

- Span consisting of ten (10) minutes of gas introduction, then an average of ten (10) 1-minute readings of a span gas with known scattering properties.
- Clean air zero consisting of five (5) minutes of internal air filtering, then an average of ten (10) 1-minute readings of particle-free air.

Detailed instructions for performing simple calibrations are included in TI 4100-3100, *Routine Site Operator Maintenance Procedures For Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*.

Record the results of the simple calibration on the Optec NGN-2 Nephelometer/Meteorology Log Sheet (site operator) or the NGN-2 Nephelometer Annual Site Visit Documentation Form (field specialist).

4.2 COMPLETE CALIBRATION

Complete calibration of NGN-2 nephelometers occurs during any of the following:

- Acceptance testing of a new instrument
- Installation or removal of a nephelometer by ARS staff
- Laboratory maintenance
- Annual or audit site visits

The HP200LX palmtop computer is used by the field specialist to control nephelometer functions and log calibration data during a complete calibration of the NGN-2 nephelometer. Complete calibration includes the following:

- Nephelometer power-on-self-test (POST) information
- Twenty (20) 1-minute clean air zero readings
- Twenty (20) 1-minute span readings

Procedures for initiating a complete calibration include:

- Attaching the span gas system to the nephelometer
- Attaching the palmtop computer to the nephelometer support system
- Executing the specific procedures outlined below.

Specific procedures are detailed as follows:

ATTACH SPAN GAS SYSTEM

Attach the span gas system to the nephelometer as follows:

- Connect the regulator input hose to the calibration gas tank outlet connector.
- Connect the rotameter input hose (bottom) to the calibration gas regulator output connector.
- Connect the span gas hose from the nephelometer to the output connector (top) of the rotameter.
- Turn the rotameter adjustment knob to the "OFF" position (fully clockwise).

ATTACH PALMTOP COMPUTER

Attach the palmtop computer to the nephelometer support system (field calibration) or directly to the nephelometer (lab calibration) using the appropriate interface cable. The cable must be attached to the bottom of the datalogger at the connector labeled "Terminal" (AMP-A directly behind the connector labeled "Phone").

SETUP DATACOMM COMMUNICATION SETTINGS

Perform the following steps to establish communications with the nephelometer:

- Turn the computer "ON."
- Press the **MORE** key.
- Close all active applications except "FILER." (To close an application, highlight the icon for that application and press **F6**).
- After all applications (except "FILER") have been closed, highlight the "DATACOMM" icon and press **F5** or **ENTER**.
- Press the "MENU" key.
- Move the cursor to "CONNECT" and press **ENTER**.
- Move the cursor down to "SETTINGS" and press **ENTER**.
- Press **O** to list stored configuration files.
- Use the "TAB" key to move the cursor to the listed files. Then highlight the nephelometer communication configuration file NEPHCOM.DCF.
- Press **F10**.
- Verify that the palmtop computer configuration settings are correct:

Baud:	9600	Data Bits:	8
Interface:	Com1	Stop Bits:	1
Parity:	None		

- If the palmtop computer configuration settings are not correct, use the "TAB" key to move the cursor from one parameter (e.g., Baud) to another parameter (e.g., Parity) and then move the cursor to the proper setting for that parameter.
- When the settings are correct, press **F10**.

OPEN A DATA FILE

Perform the following steps to open a data file:

- Press the **MENU** key.

- Move the cursor to "CONNECT' and press **ENTER**.
- Press **F5**.
- Press the **BACKSPACE** key to clear the filename entry box.
- Type the desired filename into the entry box using the following format: "**C:_DAT\SITEMMYY.DAT**," where "SITE" is the site abbreviation, "MM" is the month and "YY" is the year.

  NOTE: "STOPCAP" should be indicated on the bottom status bar on the palmtop. Note that if you have to start over for any reason, be sure to use a different file name.

- Press **ENTER**.

PERFORM A MANUAL CALIBRATION

Perform the following calibration steps:

- Reset the nephelometer by interrupting power to the nephelometer (press the red reset button on the datalogger panel).
- Quickly press **^C** several times to get the nephelometer prompt (>).
- Press **ENTER** once to get a clean line.
- If the nephelometer will not respond, disconnect the palmtop computer cable from the datalogger system. Install the circular connector adapter between the cable and the datalogger system and repeat the two preceding steps.
- Press **FN** (function) and **ZOOM** (spacebar) to see all of the printed lines.
- Verify that the nephelometer settings, date, and time are correct:

  SN (serial number) = #
  Run Mode = 3
  Intervals = 72
  Date and Time = current date and time
  Auto Span = 1
  Baud Rate = 1200
  Auto Test = 1

- Document any incorrect nephelometer settings.
- Verify that the nephelometer is set to local standard time. If the time is not correct, reset the nephelometer clock by entering the correct hour and minute. Note that the nephelometer uses a 24-hour clock (e.g., 4:30 pm would be entered as 16 hours, 30 minutes).

- When the nephelometer date, time, and configuration settings are correct, enter **POST** at the nephelometer prompt. The current nephelometer settings will be displayed on the palmtop screen and written to the open capture file.

- Manually perform the POST functions by typing the following commands, and pressing the "ENTER" key after each command:

  DOOR OPEN
  LAMP-ON
  FAN ON
  FAN OFF
  SOL ON
  SOL OFF
  VALVE ON
  VALVE OFF
  PUMP ON
  PUMP OFF

- Close the nephelometer door by typing **DOOR CLOSE**.

- Turn pump on by typing **PUMP ON**.

- Type **1 TO INTEG**.

- Type **1 20** (minutes in the field) **DO WORK LOOP**.

- After the clean air calibration cycle is complete, perform a span gas calibration. Before turning the gas on, verify that the flowmeter is turned "OFF" (fully clockwise). Turn the span gas tank valve (counter-clockwise) 1/2 turn and set the regulator to 4 psi.

- Turn the nephelometer valve on by typing **VALVE ON** and slowly adjust the flowmeter to 20 mm.

- Type **1 20** (minutes in the field) **DO WORK LOOP**.

- After the span calibration is finished, turn the span gas tank valve off.

- Disconnect the supply hose between the rotameter and tank.

- Close the flowmeter (fully clockwise).

- Perform POST calibration functions by typing the following commands (press the "ENTER" key after each command):

DOOR OPEN
FAN ON
LAMP OFF
SOL ON
VALVE OFF

To remove SUVA gas from the measurement chamber, let the instrument run for approximately five minutes, and type the following commands (press the "ENTER" key after each command):

PUMP OFF
FAN OFF
SOL OFF
DOOR CLOSE

- Press **FN** (function) and **ZOOM** (spacebar) to see the bottom status bar.
- After obtaining a valid calibration, press **F5** to close the capture file. The bottom status bar on the palmtop should indicate "CAPTURE."
- Then press **MENU**
- Highlight "QUIT" and press **ENTER**
- Press the "FILER" key on the palmtop, then press **F5**. Type or highlight the correct path, (e.g., C:_DAT). Type or highlight the correct file name and enter.
- Press **F8** "VIEW" to verify that the data were captured.
- Use the arrow keys to move through the entire file
- Press **F8** to close the viewed file.
- Press **MENU**, highlight "QUIT," and press **ENTER** to close file.
- Press **MENU**, highlight "QUIT," and press **ENTER** to close applications and return to the opening screen.
- Turn the computer off and remove the cables.

DOCUMENTING THE CALIBRATION

Place a printout of the calibration results in the instrument-specific nephelometer maintenance log book. An example of the printout is shown in Figure 4-1. Enter the results in the site-specific Quality Assurance Database.

```
RTL CPM VERSION - FOR OPTEC SBC
COPYRIGHT 1992
OPTEC, INC.  NGN-2 OPERATING SYSTEM
VERSION: NEPH1056
SN =  21
RUN MODE =  3
INTERVALS =  72
DATE & TIME (YR-MO-DAY  HR-MIN) = 960509  1641
AUTO SPAN (1 ON / 0 OFF)  1
STORED BAUD RATE = 1200
AUTO TEST (1 ON / 0 OFF) =  1
TOTAL RUN TIME = 4037 HOURS
CSUM =   23    ROMTOP =  23
                             Column

1       2         3         4         5    6            7         8

>LAMP-ON PUMP ON 1 TO INTEG
>1 15 DO WORK LOOP 1   131       4005      65        1         23.66     960509   1642
1       124 3989  62        1         23.72     960509    1643
1       123 3978  61        1         23.78     960509    1644
1       116 3971  58        1         23.81     960509    1645
1       120 3968  60        1         23.78     960509    1646
1       120 3967  60        1         23.84     960509    1647
1       118 3967  59        1         23.81     960509    1648
1       117 3967  59        1         23.84     960509    1649
1       119 3967  60        1         23.84     960509    1650
1       114 3967  57        1         23.87     960509    1651
1       118 3967  59        1         23.84     960509    1652
1       121 3968  61        1         23.90     960509    1653
1       117 3973  59        1         23.95     960509    1654
1       117 3979  58        1         23.92     960509    1655
1       120 3985  60        1         23.95     960509    1656

>VALVE ON
>1 15 DO WORK LOOP 1   144       3979      72        1         24.13     960509   1702
1       189 3980  95        1         24.19     960509    1703
1       220 3982  110       1         24.22     960509    1704
1       233 3983  117       1         24.28     960509    1705
1       241 3984  121       1         24.34     960509    1706
1       244 3986  122       1         24.39     960509    1707
1       245 3988  122       1         24.42     960509    1708
1       246 3991  123       1         24.51     960509    1709
1       246 3993  123       1         24.54     960509    1710
1       246 3995  123       1         24.57     960509    1711
1       247 3997  123       1         24.60     960509    1712
1       248 3999  124       1         24.69     960509    1713
1       246 4000  123       1         24.75     960509    1714
1       246 4001  123       1         24.78     960509    1715
1       248 4002  124       1         24.86     960509    1716
>LAMP OFF PUMP OFF VALVE OFF
```

Column	Description
1	Status: 1 = ambient air measurement 2 = clean air calibration 3 = span gas calibration 4 = lamp low or burned out 5 = rain 6 = chopper motor failure 7 = span/clean air calibration in process (D/A channel-2 output only) 8 = fog level reached
2	Raw scattered light value
3	Raw lamp brightness value
4	Normalized scattered light value
5	Integration time in minutes
6	Temperature (°C)
7	Year-Month-Day
8	Hour-Minute using 24-hour clock

Figure 4-1. Example Optec NGN Nephelometer Calibration Results Printout.

APPENDIX A

Optec NGN-2
Clean-Air Zero and Span Gas
Nephelometer Calibration Calculations

Optec NGN-2
Clean-Air Zero and Span Gas
Nephelometer Calibration Calculations

1) Calibration of the nephelometer allows conversion of the reading in counts to b_{scat}. This is a two-step process:

- The nephelometer reading in counts is converted to multiples of Rayleigh; and
- The calculated multiple of Rayleigh is multiplied by the Rayleigh coefficient (specific for each elevation) to provide b_{scat}.

2) Two calibration points are required (see accompanying Optec NGN-2 Manual Calibration Procedures): 1) A clean air (Rayleigh) value obtained by recirculating air through the nephelometer's internal clean air filter, and 2) an upscale span value obtained by introducing a gas of known scattering properties to the nephelometer chamber.

3) Nephelometer response to scattering can be represented by the linear equation y = mx + b where:

y = normalized nephelometer reading in counts
m = slope of calibration line
x = multiple of Rayleigh scattering
b = nephelometer wall scattering in counts

m and b are calculated as follows:

$$m = \frac{C_{span} - C_{zero}}{S_{span} - S_{zero}} \text{ and } b = C_{zero} - m \times S_{zero}$$

where

C_{span} = nephelometer counts during upscale span calibration (in counts)
C_{zero} = nephelometer counts during clean air calibration (in counts)
S_{span} = span gas multiple of Rayleigh scattering (e.g., F12 = 15.3)
S_{zero} = clean air multiple of Rayleigh scattering (always 1.0)

An example calibration curve is provided as Figure 1. Curves will vary between instruments.

For the measured calibration values displayed in Figure 1 of 35 counts for clean air and 200 counts for Freon-12:

$$m = 11.54 \text{ and } b = 23.5$$

Solving the calibration equation for x yields:

$$x = (y - b) / m$$

This equation can be used to determine multiples of Rayleigh scattering (x) given a normalized nephelometer reading (y).

<u>Example</u>

Assuming a normalized nephelometer reading of 100 counts and the calibration values depicted in Figure A-1, solve for x:

x = (y-b)/m
= (100 - 23.5)/11.54
= 6.63 multiples of Rayleigh

4) The nephelometer reading can be converted to b_{scat} as follows:

b_{scat} = multiples of Rayleigh * Rayleigh coefficient

The Rayleigh coefficient is a function of the elevation of the site. Table A-1 lists Rayleigh coefficients at various elevations and at various wavelengths. The NGN-2 nephelometers measure scattering at a wavelength of 550 nm.

<u>Example</u>

Assuming an elevation of sea level, the Rayleigh coefficient at a wavelength of 550 nm is:

b_{ray} = 0.01162 km^{-1}

b_{scat} is then calculated as:

b_{scat} = 6.63 * 0.01162

b_{scat} = 0.077 km^{-1}

5) Data loggers that have a **y = mx + b** option can perform the calculations necessary to calculate b_{scat} directly using the last zero and span calibration values and the site-specific Rayleigh coefficient.

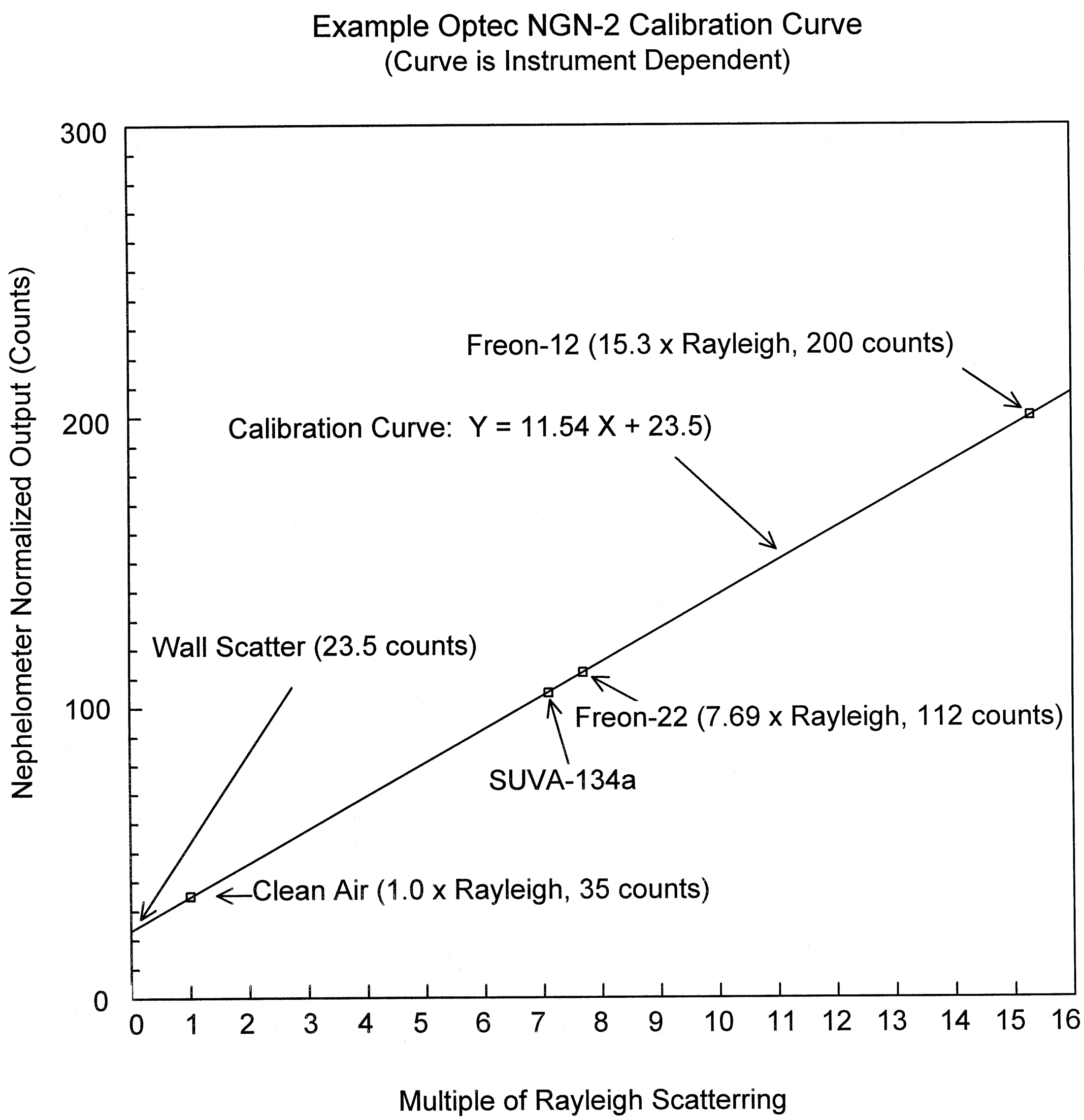

Figure A-1. Example Optec NGN-2 Calibration Curve.

Table A-1

RAYLEIGH SCATTER AS A FUNCTION OF ALTITUDE				
ALTITUDE	WAVELENGTH			
METERS/ FEET	ULTRAVIOLET 405	BLUE 450	GREEN 550	RED 630
0000/00000	.04137000	.02644000	.01162000	.00679800
100/ 328	.04025100	.02572000	.01130370	.00661200
200/ 656	.03992200	.02551000	.01121140	.00655800
300/ 984	.03959300	.02530000	.01111910	.00650400
400/ 1312	.03926400	.02509000	.01102680	.00645000
500/ 1640	.03893500	.02488000	.01093450	.00639600
600/ 1969	.03860600	.02467000	.01084220	.00634200
700/ 2297	.03827700	.02446000	.01074990	.00628800
800/ 2625	.03794800	.02425000	.01065760	.00623400
900/ 2953	.03761900	.02404000	.01056530	.00618000
1000/ 3281	.03754000	.02400000	.01055000	.00616900
1100/ 3609	.03696100	.02362000	.01038070	.00607200
1200/ 3937	.03663200	.02341000	.01028840	.00601800
1300/ 4265	.03630300	.02320000	.01019610	.00596400
1400/ 4593	.03597400	.02299000	.01010380	.00591000
1500/ 4921	.03564500	.02278000	.01001150	.00585600
1600/ 5249	.03531600	.02257000	.00991920	.00580200
1700/ 5577	.03498700	.02236000	.00982690	.00574800
1800/ 5906	.03465800	.02215000	.00973460	.00569400
1900/ 6234	.03432900	.02194000	.00964230	.00564000
2000/ 6562	.03400000	.02173000	.00955000	.00558600
2100/ 6890	.03367100	.02152000	.00945770	.00553200
2200/ 7218	.03334200	.02131000	.00936540	.00547800
2300/ 7546	.03301300	.02110000	.00927310	.00542400
2400/ 7874	.03268400	.02089000	.00918080	.00537000
2500/ 8202	.03235500	.02068000	.00908850	.00531600
2600/ 8530	.03202600	.02047000	.00899620	.00526200
2700/ 8858	.03169700	.02026000	.00890390	.00520800
2800/ 9186	.03136800	.02005000	.00881160	.00515400
2900/ 9514	.03103900	.01984000	.00871930	.00510000
3000/ 9843	.03071000	.01963000	.00862700	.00504600
3100/10170	.03038340	.01942153	.00853522	.00499239
3200/10499	.03005864	.01921424	.00844395	.00493909
3300/10827	.02973572	.01900812	.00835320	.00488609
3400/11155	.02941464	.01880317	.00826297	.00483339
3500/11483	.02909539	.01859939	.00817325	.00478099
3600/11811	.02877798	.01839678	.00808405	.00472890
3700/12139	.02846239	.01819534	.00799536	.00467710
3800/12467	.02814863	.01799507	.00790719	.00462560
3900/12795	.02783669	.01779596	.00781952	.00457440
4000/13123	.02752658	.01759801	.00773237	.00452350
4100/13451	.02721828	.01740123	.00764573	.00447290
4200/13780	.02691180	.01720560	.00755960	.00442260
4300/14108	.02660714	.01701113	.00747398	.00437259
4400/14436	.02630428	.01681782	.00738887	.00432289

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) outlines the general procedures for servicing and calibrating dataloggers used with optical monitoring systems. Accurate and reliable operation of on-site dataloggers is critical to collection of high quality optical monitoring data. Regular servicing, performance testing, and calibration of dataloggers is performed to assure quality data capture and minimize data loss by:

- Performing functional checks and performance tests annually.
- Performing preventive maintenance servicing annually.
- Recalibrating the datalogger when performance tests indicate the unit is not operating within specifications.
- Documenting all servicing, repairs, and calibrations performed.

The following technical instructions (TIs) provide detailed information regarding specific datalogger servicing and calibration procedures:

- TI 4250-2000 *Servicing and Calibration of Campbell 21X Dataloggers*
- TI 4250-2010 *Servicing and Calibration of the Handar 540A/570A DCP*
- TI 4250-2020 *Servicing and Calibration of Primeline 6723 Strip Chart Recorders*

Campbell 21X dataloggers are used as the primary datalogger for the IMPROVE nephelometer network, transmissometer calibration, and transmissometer field audits. Handar 540A/570A DCPs are used as the primary datalogger in the IMPROVE transmissometer network. Primeline 6723 strip chart recorders are used as backup dataloggers in the IMPROVE transmissometer network.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Ensure that performance testing is conducted on all data dataloggers annually.
- Ensure that fully serviced, calibrated, and field ready dataloggers are available as backups for units operating in the field.
- Ensure that all dataloggers that do not operate within factory specifications are returned to the manufacturer for factory servicing and recalibration.
- Ensure that all servicing and calibration is performed and documented according to procedures described in the datalogger-specific servicing and calibration TIs.

2.2 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Perform all servicing and calibration of optical monitoring dataloggers.
- Coordinate with the manufacturer for return of dataloggers that fail to operate within factory specifications.
- Document and archive all datalogger servicing records.

2.3 DATA COORDINATOR

The data coordinator shall:

- Inform the instrument technician when a datalogger is removed from the field.
- Provide the instrument technician with a description of the field problems observed with the datalogger.

2.4 FIELD SPECIALIST

The field specialist shall:

- Perform strip chart recorder checks annually.
- Provide the instrument technician with a description of problems observed during annual site visit testing.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The following subsections provide summary lists of test equipment and materials required to service and calibrate optical monitoring dataloggers.

3.1 CAMPBELL 21X DATALOGGER

- Calibrated voltage source
- Campbell Scientific datalogger communications software (SMCOM)
- Campbell Scientific SC532 Peripheral Interface Module
- ARS Campbell 21X datalogger test program (21X_TEST.DLD)
- Digital voltmeter
- Waveform generator
- Frequency counter
- Campbell Scientific, Inc. *21X Micrologger Operator's Manual* and *21X Prompt Sheet*

- Reference thermometer (°C)
- Replacement components as required
- Battery pack
- Battery charger
- Desiccant packets
- Standard electronics laboratory small tools
- TI 4250-2000, *Servicing and Calibration of Campbell 21X Dataloggers*

3.2 HANDAR 540A/570A DCP

- Calibrated voltage source
- RF Wattmeter with 50 ohm RF load
- Digital voltmeter
- Reference AT/RH sensor
- Handar, Inc. *Operating and Service Manual for 540A Multiple Access Data Acquisition System, 560A Hydrologic Data Collection System, and 545A Programming Set*
- Handar, Inc. *570A Data Acquisition System Operating and Service Manual*
- Handar "TERM" program
- IBM PC-compatible computer
- Spare circuit boards as required
- 12 volt battery
- Desiccant packets
- Standard electronics laboratory small tools
- TI 4250-2010, *Servicing and Calibration of the Handar 540A/570A DCP*

3.3 PRIMELINE 6723 STRIP CHART RECORDER

- Regulated 12 VDC power supply
- Calibrated voltage source
- Digital voltmeter

- Frequency counter
- Standard electronics laboratory small tools
- Soltec Distribution, *Primeline 6723 Instruction Manual*
- Stopwatch
- Replacement components (fuses, chart pens, chart paper)
- Cleaning supplies (window cleaner, alcohol, foam tip swabs)
- TI 4250-2020, *Servicing and Calibration of Primeline 6723 Strip Chart Recorders*

4.0 METHODS

This section includes three (3) subsections:

4.1 Campbell 21X Datalogger Servicing Procedures
4.2 Handar 540A/570A DCP Servicing Procedures
4.3 Primeline 6723 Strip Chart Recorder Servicing Procedures

4.1 CAMPBELL 21X DATALOGGER SERVICING PROCEDURES

Campbell 21X dataloggers are used as the primary datalogger for the IMPROVE nephelometer network, transmissometer calibration, and transmissometer field audits. Servicing procedures for the Campbell 21X datalogger are described in detail in TI 4250-2000, *Servicing and Calibration of Campbell 21X Dataloggers*. Servicing procedures include:

- Internal memory check
- Analog input check
- Analog output check
- Pulse counter check
- Panel temperature check
- Internal battery servicing
- Archiving Campbell 21X datalogger service records

4.2 HANDAR 540A/570A DCP SERVICING PROCEDURES

The Handar 540A/570A DCP is the primary datalogger in the IMPROVE transmissometer network. Servicing procedures for the Handar 540A/570A DCP are described in detail in TI 4250-2010, *Servicing and Calibration of the Handar 540A/570A DCP*. Servicing procedures include:

- Post-field inspection and performance checks

- Routine laboratory servicing
- DCP programming
- Pre-field performance testing
- Archiving Handar 540A/570A DCP service records

4.3 PRIMELINE 6723 STRIP CHART RECORDER SERVICING PROCEDURES

The Primeline 6723 strip chart recorder is used as the backup recorder in the IMPROVE transmissometer network. Servicing procedures for the Primeline 6723 strip chart recorder are described in detail in TI 4250-2020, *Servicing and Calibration of Primeline 6723 Strip Chart Recorders*. Servicing procedures include:

- Post-field inspection and performance checks
- Routine servicing
- Pre-field calibration and testing
- Archiving Primeline 6723 strip chart recorder service records

5.0 REFERENCES

Campbell Scientific, Inc., 1993, 21X Micrologger Operator's Manual. July.

Campbell Scientific, Inc., 1993, 21X Prompt Sheet.

Handar, Inc., 1982, Operating and Service Manual for 540A Multiple Access Data Acquisition System, 560A Hydrologic Data Collection System, and 545A Programming Set. June.

Handar, Inc., 1988, 570A Data Acquisition System Operating and Service Manual. March.

Soltec Distribution, Primeline 6723 Instruction Manual.

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LIST OF FIGURES

1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes procedures for servicing and verifying calibration of Campbell 21X dataloggers. This TI, as referenced in Standard Operating Procedure (SOP) 4250, *Servicing and Calibration of Optical Monitoring Dataloggers*, specifically describes procedures for:

- Testing datalogger memory functions
- Checking the accuracy of all analog voltage input channels
- Checking the accuracy of the analog output ports
- Checking the accuracy of the pulse input port
- Checking the accuracy of the panel temperature measurement
- Checking the condition of the internal battery
- Replacing the internal battery
- Archiving datalogger servicing records

Campbell 21X dataloggers are primarily used by ARS as the:

- Primary datalogger at NGN-2 nephelometer monitoring sites (Refer to TI 4300-4006, *Nephelometer Data Collection via Campbell Scientific Data Storage Module (IMPROVE Protocol)*).
- Primary datalogger for transmissometer calibration (Refer to TI 4200-2100, *Calibration of Optec LPV-2 Transmissometers (IMPROVE Protocol)*).
- Primary datalogger for field audit of transmissometers (Refer to SOP 4710, *Transmissometer Field Audit Procedures*).

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Verify that all Campbell 21X dataloggers are serviced at least annually.
- Verify that calibration checks are performed on all Campbell 21x dataloggers at least annually.
- Verify that all Campbell 21X dataloggers are operating within factory specifications prior to being shipped to the field.
- Verify that all Campbell 21X dataloggers that do not operate within factory specifications are returned to Campbell Scientific for factory servicing and recalibration.

- Ensure that all datalogger servicing is documented and archived in accordance with the procedures described in this TI.

2.2 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Perform and document all calibration checks.
- Coordinate with Campbell Scientific for return and recalibration of Campbell 21X dataloggers that fail to operate within factory specifications.
- Prepare purchase orders for factory servicing and recalibration of Campbell 21X dataloggers.
- Replace the Campbell 21X internal battery as required.
- Archive all datalogger servicing records.

2.3 DATA COORDINATOR

The data coordinator shall:

- Inform the instrument technician when a 21X is being removed from the field.
- Provide the instrument technician with a description of the field problems observed with the 21X.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Specific instrumentation, tools, equipment, and materials required to service the Campbell 21X datalogger and to verify the datalogger calibration are:

- Calibrated voltage source - Datel Model DVC-350A or equivalent
- Campbell Scientific datalogger communications software (SMCOM)
- Campbell Scientific SC532 Peripheral Interface Module
- ARS Campbell 21X datalogger test program (21X_TEST.DLD)
- Digital voltmeter (4 1/2 digits)
- Waveform generator - Wavetek Model 185 or equivalent
- Frequency counter - Tenma Model 72-375 or equivalent
- Campbell Scientific, Inc. *21X Micrologger Operator's Manual* and *21X Prompt Sheet*
- Laboratory reference thermometer (°C)

- Replacement components as required
- Medium screwdrivers (flat-blade and Phillips-head)
- Battery charger
- Replacement sealed lead acid battery pack
- Two (2) dry half-unit DESI PAK desiccant packets

4.0 METHODS

Campbell 21X dataloggers should be serviced according to the following schedule:

- Prior to installation at a field monitoring site
- On an annual schedule (for units not used at field sites)
- Any time the operation or accuracy of the datalogger appears to be suspect

Calibration of the Campbell 21X datalogger is required any time calibration checks indicate that the datalogger is not operating within factory specifications.

This section includes six (6) subsections:

4.1 Internal Memory Check
4.2 Analog Input Checks
4.3 Analog Output Checks
4.4 Pulse Counter Check
4.5 Panel Temperature Test
4.6 Internal Battery Servicing
4.7 Archiving Datalogger Service Records

Procedures for performing the internal memory check are documented on the Campbell 21X Datalogger Servicing Documentation Form (Figure 4-1) and are described in the following sections.

RECORD GENERAL INFORMATION	Record the datalogger serial number and the current date. The initials of the technician performing the inspection should also be recorded.

4.1 INTERNAL MEMORY CHECK

The Campbell 21X datalogger will perform an internal memory check on power-up. This check indicates the status of each memory chip on the datalogger's CPU board. Procedures for performing the internal memory check are documented on the Campbell 21X Datalogger Servicing Documentation Form (Figure 4-1) and are as follows:

TURN DATALOGGER ON	Turn the datalogger **ON**. The datalogger display will read "HELLO."

CAMPBELL 21X DATALOGGER
SERVICING DOCUMENTATION FORM

Date: ______________________________
Datalogger S/N: ____________________
Technician: ________________________

INTERNAL MEMORY CHECK

Memory Status = 11:111111? ☐Yes ☐No Status __:______

ANALOG INPUT CHECK

Input Voltage (mV)	Datalogger Readings (mV) CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8
0.000								
2.500								
5.000								

ANALOG OUTPUT CHECK

CAO PORT #	CORRECT OUTPUT (mV)	ACTUAL OUTPUT (mV)
#1	2500±1	
#2	5000±1	

PULSE COUNTER CHECK

Waveform Generator Frequency ____________________ Hz
Datalogger Counts ________________________________

PANEL TEMPERATURE CHECK

Ambient Temperature - Lab Reference _______________ °C
Datalogger Panel Temperature ______________________ °C

INTERNAL BATTERY SERVICING

Battery Voltage ____________________________ Volts
Battery Installation Date ____________________
Battery Replaced ☐Yes ☐No
Desiccant Replaced ☐Yes ☐No Comment ________________________________

Factory servicing or calibration required ☐Yes ☐No
Describe Servicing required ____

____

____

Figure 4-1. Campbell 21X Datalogger Servicing Documentation Form.

After a few seconds delay, the memory check results will be displayed. If all memory is installed and operating, the display will read "11:111111." The eight (8) characters in the display represent the eight (8) memory sockets numbered from left to right. A "1" indicates a good chip is in the corresponding socket. A "0" indicates the socket is empty or an error was detected in the chip. The five (5) left-most characters of the display represent the 8K ram chips. The three (3) right-most characters of the display are the 8K PROMs.

If the memory check results indicate that one or more memory chips are faulty, return the instrument to Campbell Scientific for repair.

4.2 ANALOG INPUT CHECKS

CONNECT VOLTAGE CALIBRATOR	Connect the Datel voltage calibrator to the datalogger using the datalogger "analog inputs" test cable. This cable provides a connection from the voltage output of the calibrator to each of the eight (8) analog input channels of the datalogger.
DOWNLOAD TEST PROGRAM	Download the datalogger test program (21X_TEST.DLD) to the datalogger to be tested using the Campbell Scientific datalogger communications software (SMCOM) and the Campbell Scientific SC532 Peripheral Interface Module.
RUN TEST PROGRAM	Press ***0** on the datalogger to compile and run the test program.
SET VOLTAGES	Set the calibrator to the input voltages specified on the Campbell 21X Datalogger Servicing Documentation Form (Figure 4-1). All input voltages are specified in millivolts. All datalogger readings should be recorded as millivolts.
RECORD DISPLAY READINGS	Enter ***6** on the datalogger and record the datalogger display reading (storage locations 01 - 08) for each of the eight analog channels at each of the three input voltages specified on the Campbell 21X Datalogger Servicing Documentation Form. If the datalogger readings for any of the analog channels differ from the specified values by more than ± 5.0 millivolts, return the datalogger to Campbell Scientific for recalibration.

4.3 ANALOG OUTPUT CHECKS

The test program sets up a continuous DC voltage output on both analog output ports (CAO 1 and CAO 2).

MEASURE OUTPUT VOLTAGE	Measure the output voltage at CAO ports 1 and 2 with a calibrated and certified 4 ½ digit voltmeter. Record these measurements (in millivolts) on the Campbell 21X Datalogger Servicing

Documentation Form. The correct reading for each port is shown, along with the manufacturers' specified accuracy, on the Campbell 21X Datalogger Servicing Documentation Form.

If the datalogger readings for either CAO port differ from the specified values by more than ± 5.0 millivolts, return the datalogger to Campbell Scientific for recalibration.

4.4 PULSE COUNTER CHECK

CONNECT GENERATOR TO FREQUENCY COUNTER — Connect the waveform generator to pulse input channel #1.

SETUP WAVEFORM GENERATOR — Setup the waveform generator for a square wave output with a frequency of 1000 Hz and an amplitude of 1 volt(rms).

RECORD COUNTS — The test program will count pulses from the waveform generator for a period of 10 seconds. Record the number of counts in the pulse counter channel at storage location 09 (press ***6 9** on the datalogger). Based on an input frequency of 1000 Hz, a datalogger count of 10,000 should be displayed.

If the datalogger reading for the pulse counter channel differs from the specified value by more than ± 5 counts, return the datalogger to Campbell Scientific for recalibration.

4.5 PANEL TEMPERATURE CHECK

RECORD AMBIENT TEMPERATURE — Read the ambient temperature in the laboratory with the laboratory reference thermometer. Record this temperature (°C) on the Campbell 21X Datalogger Servicing Documentation Form (Figure 4-1).

RECORD PANEL TEMPERATURE — Read the datalogger panel temperature at storage location 10 (press ***6 10** on the datalogger) and record the reading on the Campbell 21X Datalogger Servicing Documentation Form.

If the datalogger panel temperature measurement differs from the laboratory reference thermometer reading by more than ± 1.7 °C, return the datalogger to Campbell Scientific for recalibration.

4.6 INTERNAL BATTERY SERVICING

RECORD BATTERY VOLTAGE — Read the internal battery voltage at storage location 11 (press ***6 11** on the datalogger). Record this reading on the Campbell 21X Datalogger Servicing Documentation Form.

RECHARGE BATTERY — If the battery voltage is less than 11.76 volts, connect the datalogger to the battery charger. Recharge the battery for eight (8) hours.

REPLACE BATTERY — Disconnect the datalogger from the battery charger and recheck the battery voltage (press ***6 11** on the datalogger). If the battery voltage is still less than 11.76 volts, replace the battery as described below:

- Turn the power switch **OFF**.
- Remove the two front panel screws and carefully raise the front panel away from the datalogger case.
- Disconnect the used battery from the charging circuit and remove from the datalogger case.
- Install a fresh battery. Mark the installation date on the battery.
- Remove the datalogger desiccant packets and replace with two (2) dry half unit DESI PAK desiccant packets.
- Replace the front panel.
- Turn the power switch **ON** and recheck the battery voltage.

4.7 ARCHIVING DATALOGGER SERVICE RECORDS

All service records for Campbell 21X dataloggers are maintained by the instrument technician. The records are archived by datalogger serial number in three-ring notebooks located in the ARS instrumentation laboratory.

5.0 REFERENCES

Campbell Scientific, Inc., 1993, 21X Micrologger Operator's Manual. July.

Campbell Scientific, Inc., 1993, 21X Prompt Sheet.

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes procedures for servicing and calibration testing of Handar 540A/570A Data Collection Platforms (DCPs). This TI, as referenced in Standard Operating Procedure 4250, *Servicing and Calibration of Optical Monitoring Dataloggers*, specifically describes procedures for:

- Performing post-field inspections
- Performing post-field timing and performance checks
- Performing routine laboratory servicing and cleaning
- Checking and performing laboratory modifications
- Programming the DCP
- Performing pre-field operational tests
- Documenting all servicing tasks
- Archiving servicing, repair, and calibration records

Handar 540A/570A DCPs are used as the primary dataloggers in the IMPROVE transmissometer network.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Verify that all Handar 540A/570A DCPs are serviced at least annually.
- Verify that calibration, timing, and transmission checks are performed on all Handar 540A/570A DCPs at least annually.
- Verify that all Handar 540A/570A DCPs are operating within factory specifications prior to being shipped to the field for use at an operational monitoring site.
- Verify that all Handar 540A/570A DCPs that do not operate within factory specifications are returned to Handar for factory servicing and recalibration.
- Ensure that all DCP servicing is documented and archived in accordance with the procedures described in this TI.

2.2 INSTRUMENT TECHNICIAN

The instrument technician shall:

- Perform and document all servicing, modifications, calibration checks, and operational tests.

- Coordinate with Handar for return, servicing, and recalibration of 540A/570A DCPs that fail to operate within factory specifications.

- Prepare purchase orders for factory servicing and recalibration of Handar 540A/570A DCPs.

- Replace the Handar 540A/570A internal battery as required.

- Archive all DCP servicing records.

2.3 DATA COORDINATOR

The data coordinator shall:

- Inform the instrument technician when a DCP is being removed from the field.

- Provide the instrument technician with a description of the field problems observed with the DCP.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Specific instrumentation, tools, equipment, and materials required to service and test the Handar 540A/570A DCP are as follows:

- Calibrated voltage source - Datel Model DVC-350A or equivalent

- RF wattmeter - Bird Model 43 with #250D power element and 50 ohm RF load or equivalent

- Digital voltmeter (4 1/2 digits)

- Handar, Inc. *Operating and Service Manual for 540A Multiple Access Data Acquisition System, 560A Hydrologic Data Collection System, and 545A Programming Set*

- Handar, Inc. *570A Data Acquisition System Operating and Service Manual*

- Handar "TERM" program (DCP communication and interface software)

- IBM PC-compatible computer

- Spare circuit boards as required

- Replacement internal 12 volt battery

- Two (2) packs desiccant

- Reference AT/RH sensor (Rotronics GT-L or equivalent)

- Rotronics AT/RH Sensor (Model MP-100F, wired for use with the Handar 540A/570A DCP)

- Electronic contacts cleaning fluid

- Medium screwdrivers (flat-blade and Phillips-head)

4.0 METHODS

Handar 540A/570A DCPs should be serviced according to the following schedule:

- Prior to installation at a field monitoring site

- On an annual schedule

- Any time the operation or accuracy of the datalogger appears to be suspect

Factory servicing and calibration of the Handar 540A/570A DCP is required when timing and performance checks indicate that the DCP is not operating within factory specifications.

This section includes five (5) major subsections:

4.1 Post-Field Inspection and Performance Checks
4.2 Routine Laboratory Servicing
4.3 DCP Programming
4.4 Pre-Field Performance Testing
4.5 Archiving Handar 540A/570A DCP Service Records

4.1 POST-FIELD INSPECTION AND PERFORMANCE CHECKS

When a DCP is returned from a field site, the external and internal physical condition is visually inspected prior to performing any performance tests or laboratory servicing. If the DCP is received with the power switch in the "ON" position and there are no loose circuit boards, disconnected or damaged connectors, or other apparent problems that might affect the operation of the DCP, performance tests that evaluate DCP timing, A/D converter operation, transmission power, and the DCP program are performed. Results and comments related to inspection and performance testing are fully documented on the Post-Field Inspection Checklist - Handar 540A/570A DCP (Figure 4-1).

4.1.1 <u>General Information</u>

RECORD GENERAL INFORMATION	Record the DCP serial number, the site it was received from, and the date it was received. The initials of the technician performing the inspection should also be recorded.
IDENTIFY DCP MODEL	Identify the DCP model (Figure 4-2 shows the front panel layout of each of the three DCP models used by ARS).
NOTE REASON FOR RETURN	Note whether the DCP was returned for annual servicing (no observed operational problems in the field) or for unscheduled maintenance (unit malfunctioning). If returned for unscheduled maintenance, describe the observed field symptoms.

POST-FIELD INSPECTION CHECKLIST
HANDAR 540A/570A DCP

DCP S/N: ______________________________
Site: ______________________________
Date: ______________________________
Technician: ___________________________

DCP Model: ☐540A1 ☐540A2 ☐570A
Received for: ☐Annual Servicing ☐Unscheduled Maintenance
Reason for unscheduled maintenance ____
____
____

PHYSICAL INSPECTION - EXTERNAL

Describe "as returned" condition of the following:

DCP Case ____
Case Latches ____
Connectors/Contacts ____
Display (570A Only) ____
Door Seal ____

PHYSICAL INSPECTION - INTERNAL

Describe "as returned" condition of the following:

Power switch ☐On ☐Off
GOES Radio Channel 1 ☐900 ☐Other ______________________________
GOES Radio Channel 2 ☐000 ☐Other ______________________________
Circuit Boards, Hold Down Bracket, Connectors ____________________________
Battery and Hold Down Bracket ____
Battery Voltage ________________ Volts

DCP TIMING CHECKS

Program in Memory ☐Yes ☐No
DCP ID [I] _________________________
DCP Time [J] __ __ : __ __ : __ __ WWV Time __ __ : __ __ : __ __
DCP Time to Next Scan [S] __ __ : __ __ : __ __
DCP Time to Next Transmit [T] __ __ : __ __ : __ __

DCP A/D CONVERTER CHECKS

Test Input Ch. 1,2,3	DCP Channel # (Output) CH1	CH2	CH3	CH4	CH5	CH10
0.000 Volts	________	________	________	________	________	________
4.950 Volts	________	________	________	________	________	________
Lab AT/RH				________	________	

TRANSMISSION TEST

Forced Transmit RF Power Output ____________________ Watts

Figure 4-1. Post-Field Inspection Checklist - Handar 540A/570A DCP.

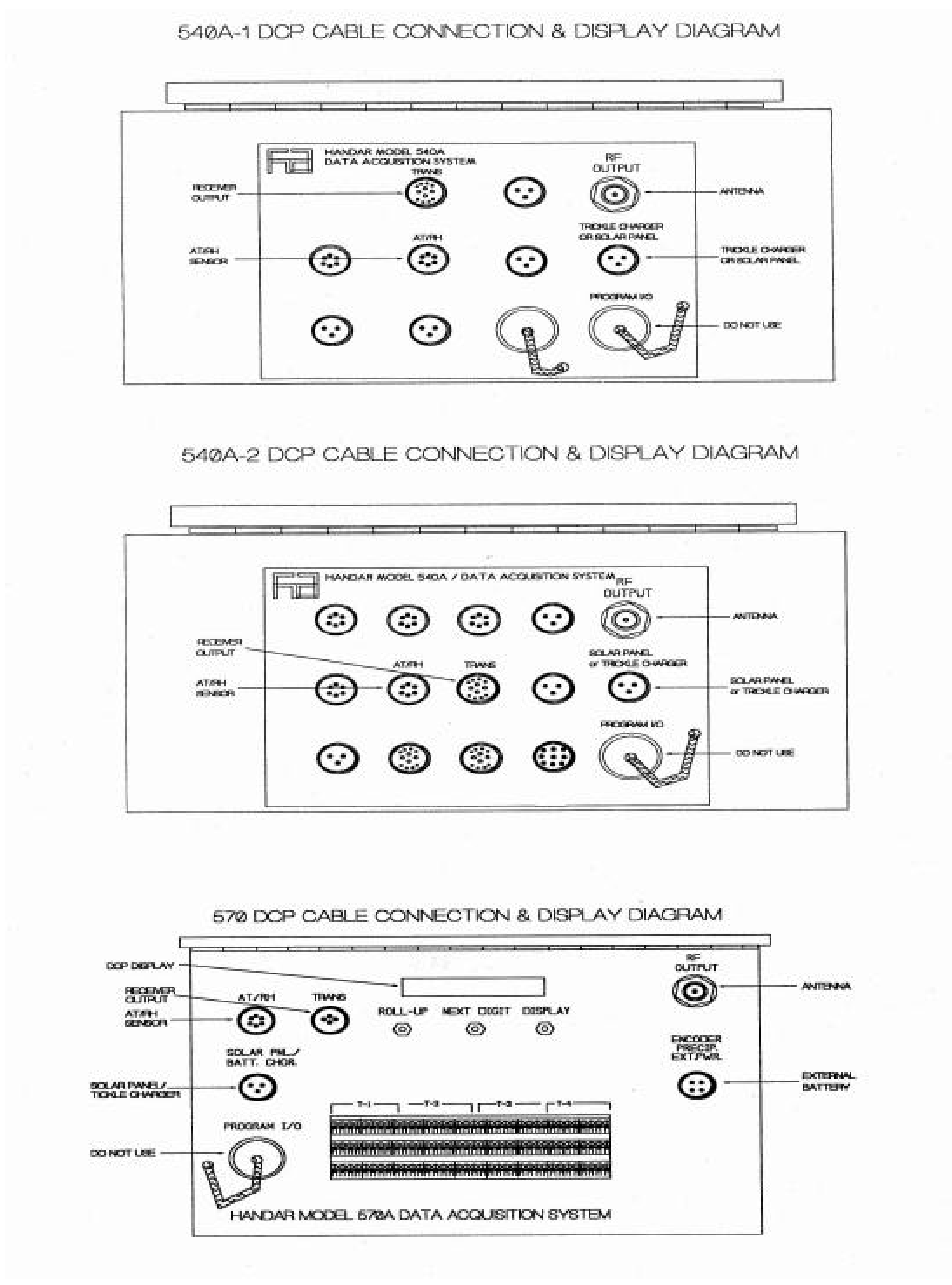

Figure 4-2. Front Panel Configurations - Handar 540A/570A DCP.

4.1.2 Physical Inspection - External

INSPECT CASE	Inspect the outside of the DCP case thoroughly. Look for signs of external damage (dented, scraped, or gouged surfaces). Examine the latches and external connectors. Describe any damage or general deterioration noted.
RECORD DISPLAY	If the DCP is a model 570A, step through the display, recording the readings displayed for each channel.
INSPECT SEAL	Open the cover on the DCP and inspect the seal between the cover and the case. Look for loose sections of seal, tears, and worn spots.

4.1.3 Physical Inspection - Internal

NOTE POWER	Note whether the power switch is "ON" or "OFF" (see Figure 4-3 for switch location).
NOTE CHANNEL SETTINGS	Note the settings of the GOES primary channel (#1) and secondary channel (#2) switches (see Figure 4-3 for switch locations). The GOES primary channel selection switch should be set to "900" (inhibits transmission). The GOES secondary channel selection switch should be set to "000" (channel unused). If the switches are not set properly, they should be reset to these channel numbers before proceeding with this inspection.
INSPECT DCP INTERIOR	Inspect the interior of the DCP, checking that all circuit boards are firmly seated, all hold-down brackets are in place and secure, and all cables and connectors are undamaged and in place. Describe any improper conditions.
MEASURE BATTERY VOLTAGE	Measure the internal battery voltage. If it is less than 11.8 volts, connect a current limited power supply set at 16 volts and 500 ma to the DCP Solar Panel/Battery Charger input for a period of 24 hours. If the battery voltage does not reach a minimum voltage of 13.8 volts, it must be replaced during servicing.
CHECK INSTALLATION DATE	Check the installation date on the battery. If the battery is more than 5 years old, it must be replaced during servicing, regardless of the battery's state of charge.

4.1.4 DCP Timing Checks

PROGRAM	**NOTE!** If the DCP power switch was off, or has been MEMORY turned off for any reason, the program and timing will have been lost from the DCP memory and this section of the post-field inspection should be omitted.
EXECUTE PROGRAM	Execute the Handar DCP communications program "TERM" from the IBM PC-compatible computer.

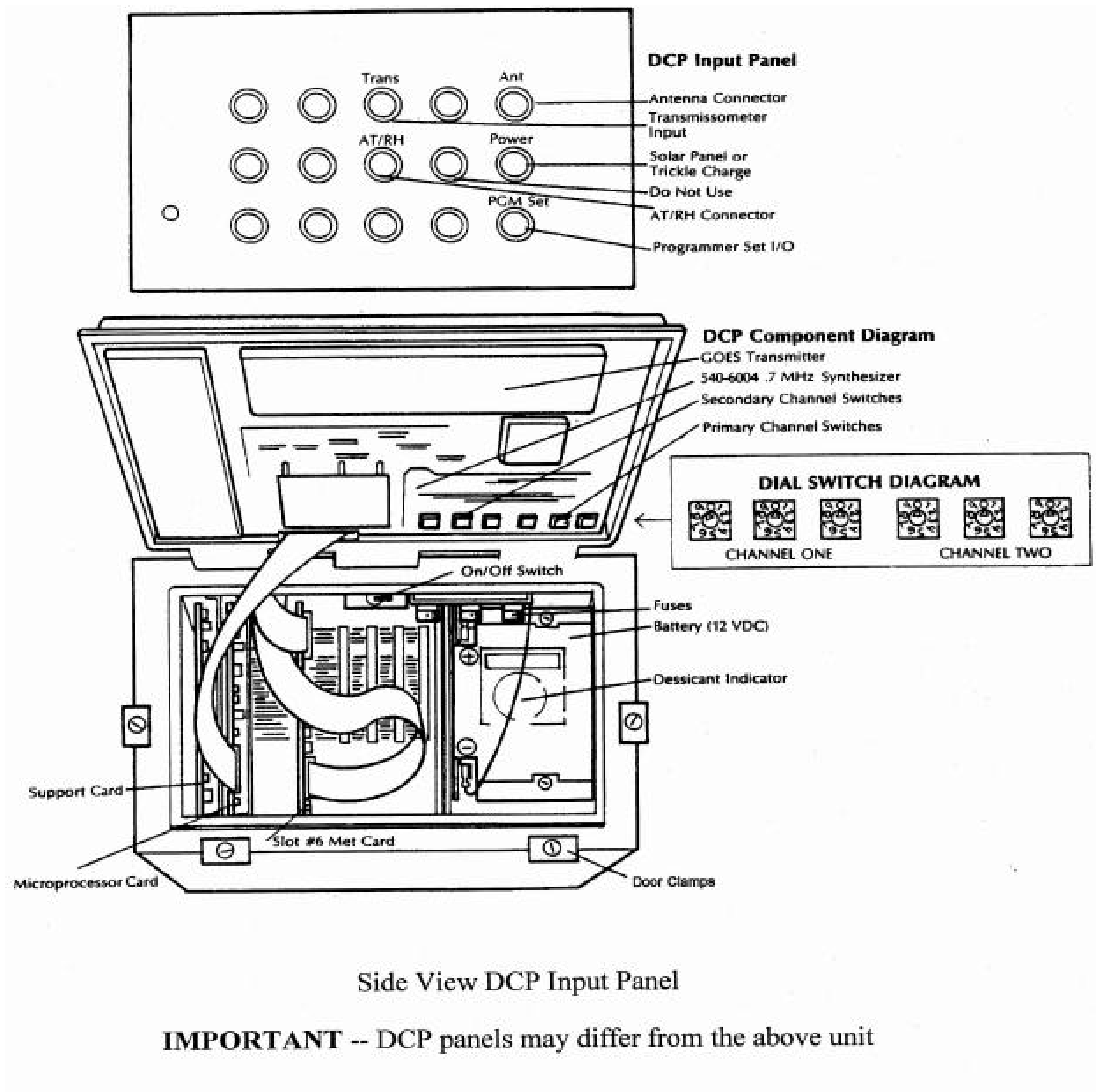

Figure 4-3. DCP Component Diagram.

SWITCH BAUD RATE	When the "TERM" setup screen (see Figure 4-4) is displayed on the computer screen, press **F2** to switch to the correct baud rate (300 baud).
CONNECT COMPUTER TO DCP	Connect the serial port of the computer to the DCP programming port (see Figure 4-2 for location) using the DCP programming cable. After the connection is complete, the "TERM" programming screen (Figure 4-5) should be displayed on the computer screen.
NOTE DISPLAY	If the program is still in memory, the computer display should be as shown in Figure 4-5. **If the computer display appears as in Figure 4-6, the program has been lost from memory and the DCP performance and timing checks should be terminated. Exit the "TERM" program and turn the DCP off before initiating the servicing procedures. Be sure and document that the program was no longer in memory.**
SYNCHRONIZE TIME	Verify that your watch is synchronized with WWV by calling the NIST WWV time transmission telephone (303/499-7111).
ENTER PARAMETERS	Obtain DCP ID and timing information by entering into the DCP the boldface character that precedes each of the following parameters: • **I** Station ID • **J** DCP time • **S** Time remaining before next scan • **T** Time remaining before next transmission
RECORD VALUES	Record each of the values from the ID and timing checks and the correct (WWV) time when the DCP time check, [J], was performed.
COMPARE TIMES	Compare the DCP times to the correct time to determine the timing drift relative to previous measurements (at installation or from recent transmissions - Refer to TI 4300-4000, *Data Collection via DCP (IMPROVE Protocol)*.

4.1.5 DCP A/D Converter Checks

CONNECT VOLTAGE SOURCE	Connect a calibrated voltage source to the input of data channels 01, 02, and 03 of the DCP.
CONNECT AT/RH SENSOR	Connect a calibrated Rotronic AT/RH sensor to the DCP's AT/RH input connector.

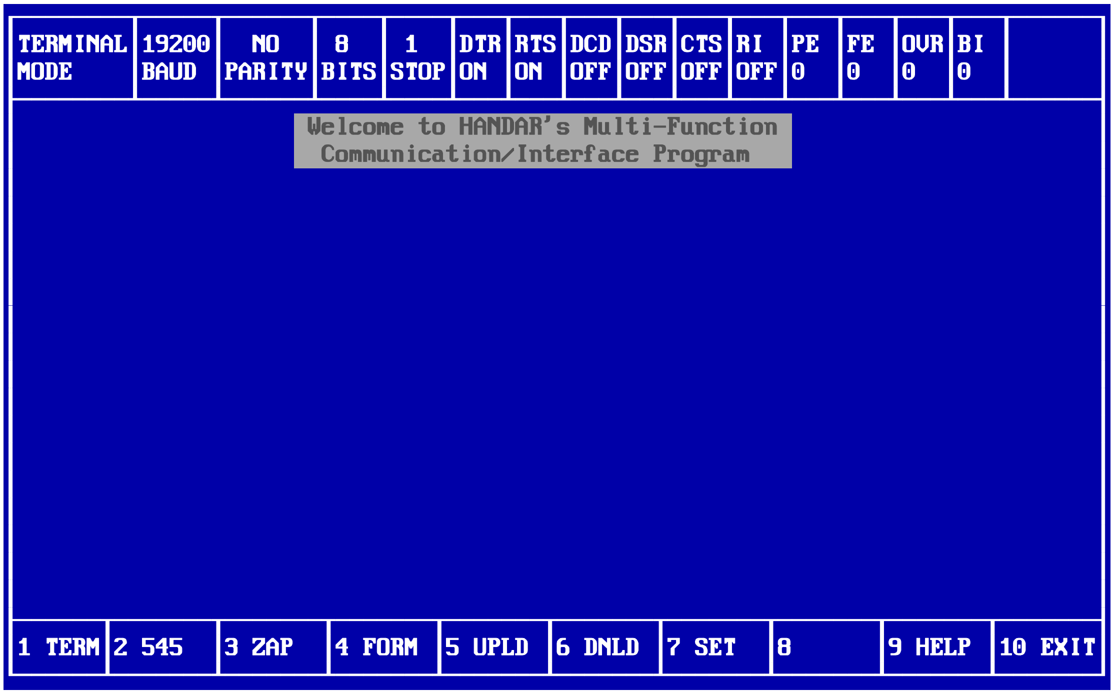

Figure 4-4. **TERM** Setup Screen.

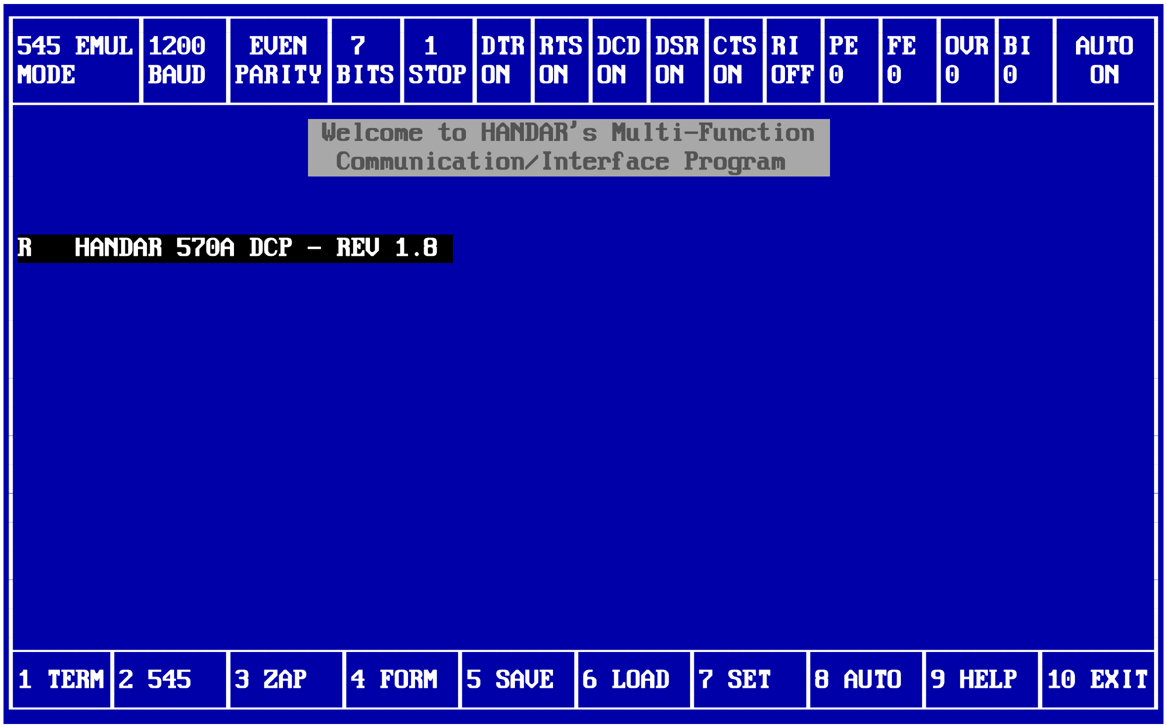

Figure 4-5. "TERM" DCP Programming Screen (Program in DCP Memory).

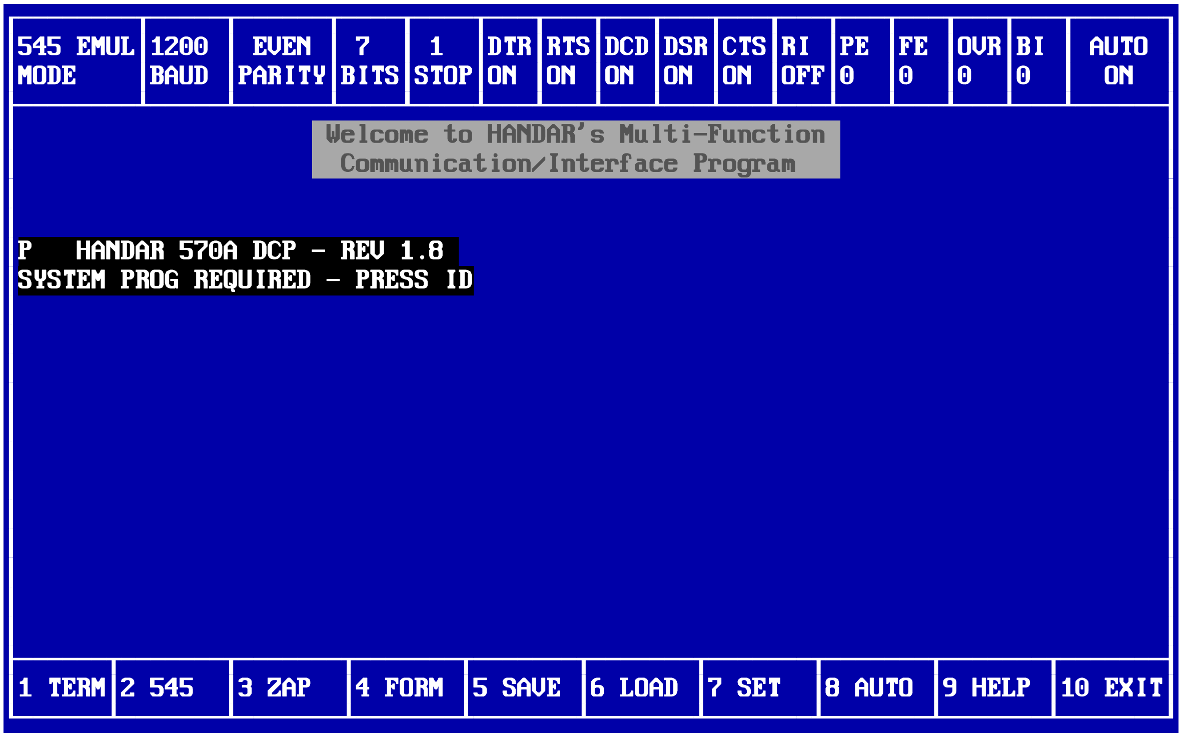

Figure 4-6. **TERM** DCP Programming Screen (No Program in DCP Memory).

SWITCH MODES	Switch the DCP from "RUN" mode to "PROGRAM" mode by entering **?**. The computer display will read "R Enter (1) = Service (2) = All." Enter **2** to select "ALL."
SET OUTPUT	Set the output of the calibrated voltage source to 0.000 volts.
OBTAIN READINGS	Obtain DCP readings for data channels 01, 02, and 03 using the following procedure: • Enter **M** (access data channel 01 - transmissometer raw readings). • Enter **$** (execute a forced scan). • Record the DCP reading for data channel 01. • Enter **V** (scroll down to data channel 02 - transmissometer toggle signal). • Enter **$** (execute a forced scan). • Record the DCP reading for data channel 02. • Enter **V** (scroll down to data channel 03 - transmissometer standard deviation). • Enter **$** (execute a forced scan). • Record the DCP reading for data channel 03. With a 0.000 volt input, DCP data channels 01, 02, and 03 should all read "000."
SET OUTPUT VOLTAGE	Set the output of the calibrated voltage source to 4.950 volts.
OBTAIN READINGS	Obtain DCP readings for data channels 01-05 and 10 using the DCP procedures described above for obtaining DCP readings for data channels 01, 02, and 03.
OBTAIN AT/RH	Obtain current laboratory measurements of ambient temperature and relative humidity using the Rotronic GT-L hand held AT/RH sensor. Record these values on the inspection checklist (DCP A/D Converter Checks section) under channel 04 and channel 05, respectively.
NOTE READINGS	With a 4.950 volt input, DCP data channels 01 and 03 should read "495." DCP data channel 02 should read "001."

COMPARE READINGS	The DCP data channel 04 reading (Rotronics AT output signal) must be adjusted by subtracting 100 from the reading obtained during the test. Compare this adjusted reading with the temperature measurement obtained with the hand held sensor. The two values should then match within ± 2 F°.
	Compare the DCP data channel 05 reading (Rotronics RH output signal) with the RH measurement obtained with the hand held sensor. The two values should agree within ± 3%.
	Compare the DCP data channel 10 reading (DCP internal battery voltage) with the internal battery voltage measured during the DCP internal physical inspection. The two values should agree within ± 0.005 volts.

4.1.6 Transmission Test

CONNECT WATTMETER	Connect an RF wattmeter (with a 200-500 mHz, 25-watt power element) to the "RF Output" connector located on the front panel of the DCP. A 50 Ohm, 25-watt load resistor should be connected to the output of the wattmeter.
SET CHANNEL SWITCHES	Set the GOES primary channel select switches to the channel number assigned to the ID programmed for the DCP under test.
INITIATE TRANSMISSION	With the DCP in "PROGRAM" mode, initiate a transmission by entering **#**.
RECORD READING	The wattmeter should read 10 ± 2 watts. Record the observed reading on the Post-Field Inspection Checklist - Handar 540A/570A DCP (Figure 4-1).
RESET SWITCHES	Reset the GOES primary channel select switches to **900**.

4.2 ROUTINE LABORATORY SERVICING

Record and document all information and procedures on the Routine Servicing Checklist - Handar 540A/570A DCP (Figure 4-7).

RECORD GENERAL INFORMATION	Record the DCP serial number, the site it was received from, and the date it was received. The initials of the technician performing the inspection should also be recorded.
IDENTIFY DCP MODEL	Identify the DCP model (Figure 4-2 shows the front panel layout of each of the three DCP models used by ARS).
NOTE REASON FOR RETURN	Note whether the DCP was returned for annual servicing (no observed operational problems in the field) or for unscheduled maintenance (unit malfunctioning). If returned for unscheduled maintenance, describe the observed field symptoms.

ROUTINE SERVICING CHECKLIST
HANDAR 540A/570A DCP

DCP S/N: ____________________________
Date: _______________________________
Technician: __________________________

DCP Model: ☐540A1 ☐540A2 ☐570A

Received for: ☐Annual Servicing ☐Unscheduled Maintenance

Reason for unscheduled maintenance ____
____
____

SETUP

☐ GOES Primary Channel Select Switches Set to 900

☐ GOES Secondary Channel Select Switches Set to 000

EXTERNAL CLEANING

☐ Front Panel Connector Contacts Cleaned

☐ Connector Mounting Screws Tightened

BATTERY REPLACEMENT

Internal 12-Volt Battery Replaced ☐ Yes ☐ No

INTERNAL CLEANING

☐ Plug in Circuit Board Connector Contacts Cleaned

☐ Backplane Connector Contacts Cleaned

☐ Inside of DCP Cleaned

570A MODIFICATIONS

Toggle Input ☐ Modified During Servicing ☐ Previously Modified

AT/RH Interface ☐ Modified During Servicing ☐ Previously Modified

540A MODIFICATION

AT/RH Interface ☐ Modified During Servicing ☐ Previously Modified

Figure 4-7. Routine Servicing Checklist - Handar 540A/570A DCP.

VERIFY GOES SWITCHES	Verify that the GOES primary channel select switches are set to “900” and the secondary channel select switches set to "000." If the switches are not set to these channels, they must be reset prior to continuing with servicing of the DCP.
CLEAN EXTERNAL CONTACTS	Spray the contacts on all external (front panel) connectors with contact cleaner.
CHECK MOUNTING SCREWS	Check the mounting screws for all front panel connectors. Loose screws should be tightened.
REPLACE BATTERY	If the battery is more than five (5) years old (as indicated by the installation date marked on the battery), or if the battery failed the battery test during inspection, the battery must be replaced. Battery replacement procedures are as follows: • Turn the power switch **OFF**. • Disconnect any external power source (battery or battery charger) from the DCP. • Disconnect the DCP internal battery connectors. • Remove the circuit board hold-down bracket. • Remove the battery hold-down bracket. • Lift the battery out of the DCP case. • With a permanent marker, write the installation date on the new battery. • Place the new battery in the DCP case. • Replace the battery hold-down bracket.
CLEAN CIRCUIT BOARD	Check the power switch. If it is not "OFF," turn it **OFF**. Remove the DCP plug-in circuit boards. Clean printed circuit board's edge connector contacts and the ribbon cable connector contacts with contact cleaner.
CLEAN BACKPLANE CONNECTORS	Clean the backplane connectors with contact cleaner. Clean the contacts on the ribbon cable connectors with contact cleaner.

CLEAN INTERIOR OF DCP

Clean the inside of the DCP with compressed air.

MODIFY 570A TOGGLE INPUT VOLTAGE DIVIDER

If this is a Handar 570A DCP, the transmissometer toggle input (DCP data channel 02) voltage divider must be modified to ensure that the voltage divider always exceeds 3.0 volts when the toggle input is at a logic "high" level. Modify the toggle input voltage divider located on the 12-bit A/D Converter (ADC) board using the following procedures:

- Remove the component platform in socket U17 of the ADC board (see Figure 4-8 for the location of U17).
- Examine resistor R17-6 located between pins 6 and 11 of the component platform (the resistor location on the component platform is shown in Figure 4-8). If the modification has been implemented, this resistor value will be 4.02K Ohms. If it is not 4.02K, remove the existing resistor (1.00K) and replace it with a 4.02K resistor.
- Replace the component platform in socket U17 of the ADC board.

MODIFY 570A FOR AT/RH SENSOR

If this is a Handar 570A DCP, the AT/RH sensor interface circuit on the ADC board must be modified to accept the Rotronics MP100-F AT/RH sensor. To modify the sensor interface circuit, remove the component platform from socket U7 of the ADC board (refer to Figure 4-8 for the location of U7).

MODIFY 540A FOR AT/RH SENSOR

If this is a Handar 540A DCP, the AT/RH sensor interface circuit on the Met board must be modified to accept the Rotronics MP100-F AT/RH sensor. To modify the sensor interface circuit, remove resistor R8 (see Figure 4-9 for the location of R8).

REINSTALL CIRCUIT BOARDS

If this is a Handar 570A DCP, reinstall the ADC board in slot #1.

If this is a Handar 540A DCP, reinstall the circuit boards in the slots numbered as follows:

- Slot #6 Met board
- Slot #8 Microprocessor board
- Slot #9 Support board

Replace the circuit board hold-down bracket.

Reconnect the ribbon cables.

Reconnect the DCP internal battery connectors to the battery.

Turn the power switch **ON**.

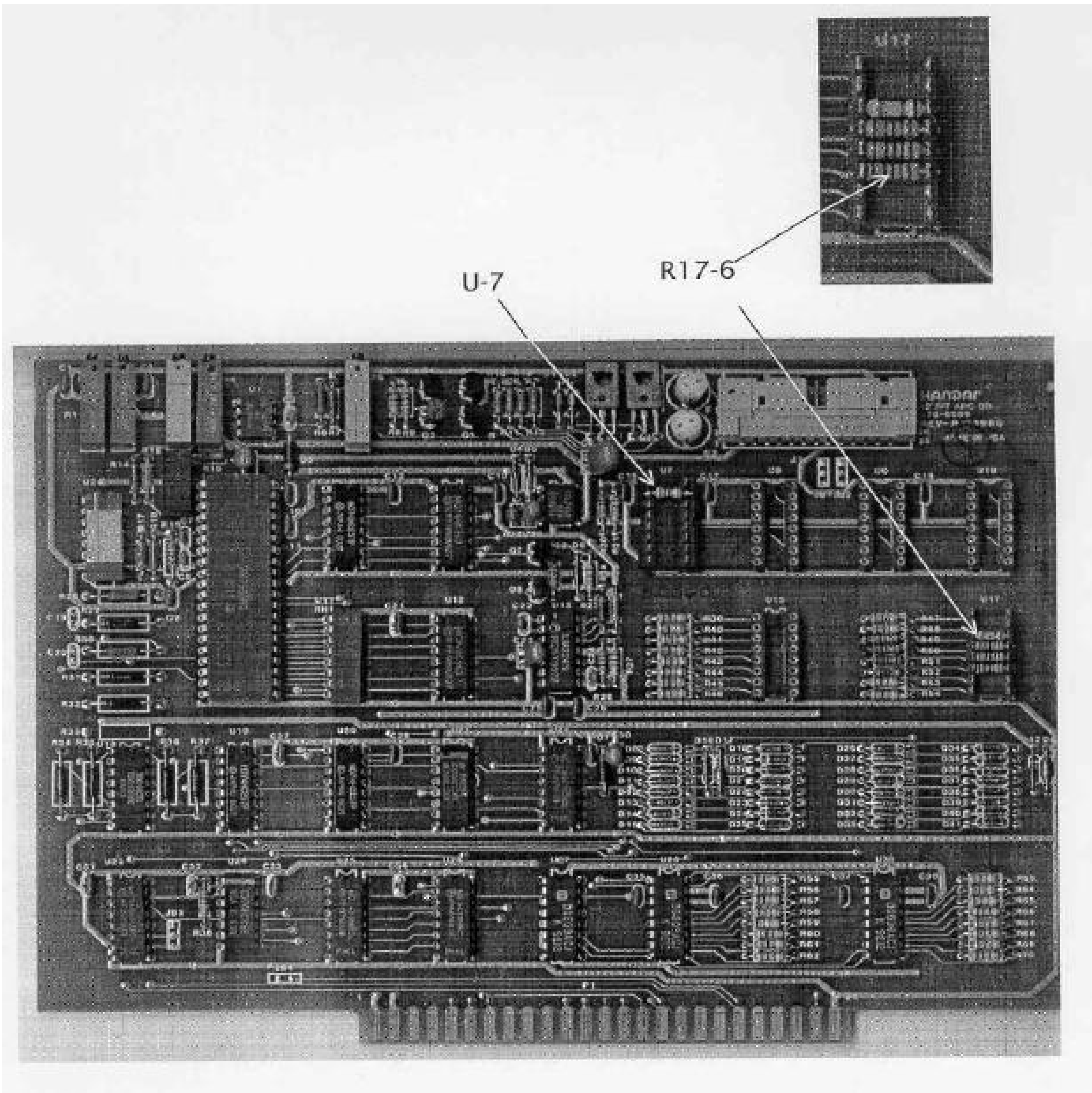

Figure 4-8. Handar 570A ADC Board - Component Locations.

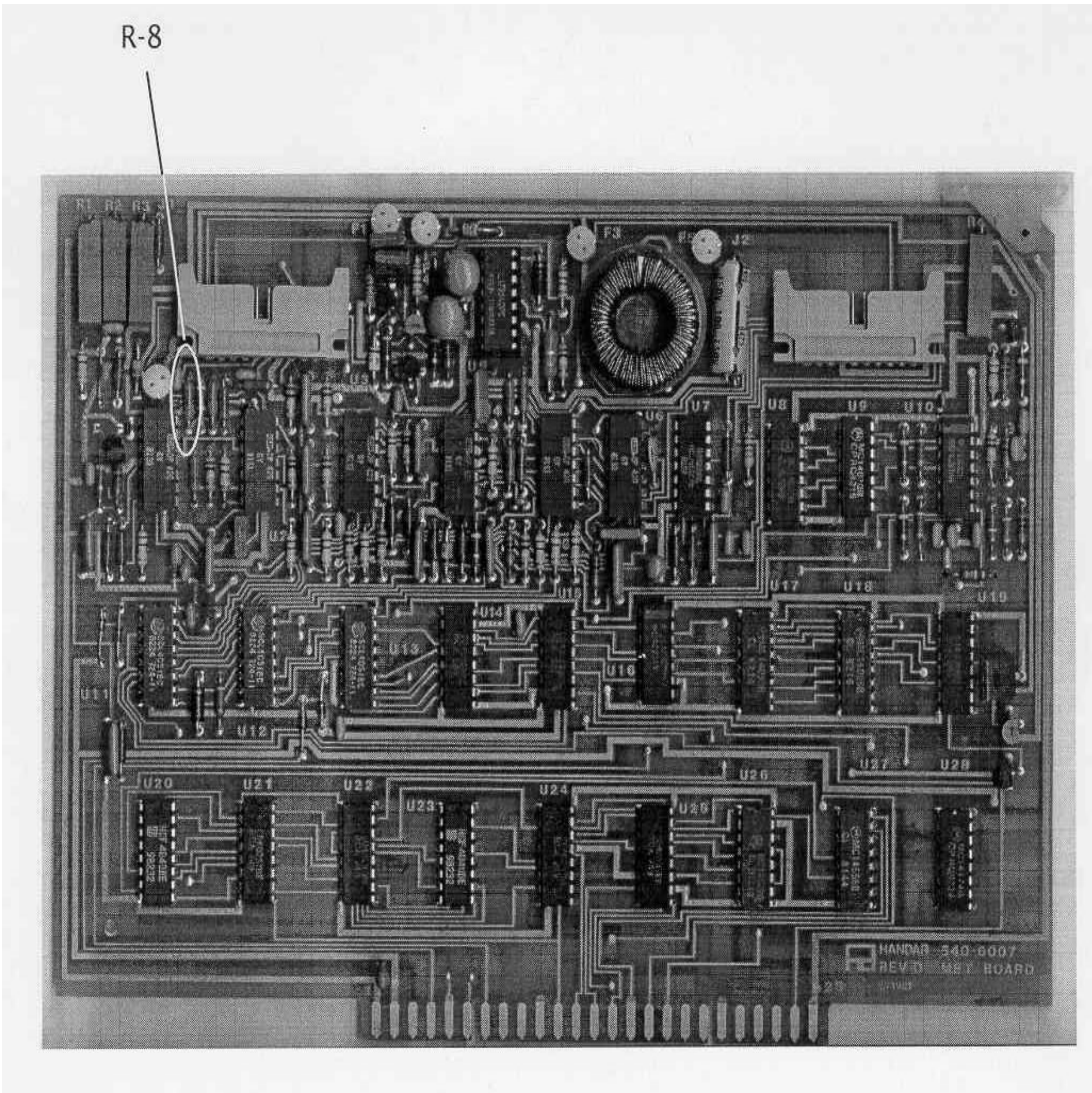

Figure 4-9. Handar 540A Met Board - Component Locations.

4.3 DCP PROGRAMMING

The Handar 540A/570A DCP operational configuration is established through a user program that performs the following functions:

- Defines the external sensors and signal inputs to be used
- Specifies the data acquisition channels associated with each sensor or input
- Defines processing options
- Selects reporting modes and formats
- Sets scanning, reporting, and transmission schedules

Basic concepts relating to the data acquisition functions of the Handar 540A/570A DCP are described in detail in Section 6.1 of the Handar *570A Data Acquisition System Operating and Service Manual*.

For DCPs used with the IMPROVE transmissometer network, the most recent version of the standard DCP configuration program is available as an ASCII file, either 540ROT.DCP (Refer to Appendix A for a complete listing of the 540ROT.DCP configuration program) or 570ROT.DCP (Refer to Appendix B for a complete listing of the 570ROT.DCP configuration program), depending on the type of DCP to be programmed. The standard program file is first downloaded to the DCP.

After downloading, the program in the DCP is edited to include the site-specific operating parameters (see Table 4-1 for a list of station IDs, GOES channel assignments, and transmit times for all IMPROVE transmissometer sites) listed below:

- Station ID
- Transmit time

GOES channel selection is controlled by the DCP channel selection switches, not by the DCP configuration program.

Procedures for downloading the standard DCP configuration program are as follows:

VERIFY GOES SWITCHES	Verify that the GOES primary channel select switches are set to "900" and the secondary channel select switches set to "000." If the switches are not set to these channels, they must be reset prior to continuing with programming of the DCP.
SYNCHRONIZE TIME	Verify that your watch is synchronized with WWV by calling the NIST WWV time transmission telephone (303/499-7111).
DELETE DCP MEMORY	Ensure that there is no program stored in the DCP memory by turning the power switch to **OFF**, then turning it back to **ON** (refer to Figure 4-3 for switch location).

Table 4-1

DCP ID Assignments
IMPROVE Transmissometer Network

DCP-ID	CHAN	LOCATION	TIME *	RATE **
FA43DOBE	014W	Fort Collins (Test)	0200	X3
FA43F652	014W	Grand Canyon (In-Canyon)	0202	X3
FA441794	014W	Glacier	0204	X3
FA44C1FC	014W	Rocky Mountain	0215	X3
FA44D28A	014W	Grand Canyon (South Rim)	0216	X3
FA44E710	014W	Great Basin	0217	X3
FA44F466	014W	Canyonlands	0218	X3
FA450618	014W	Chiricahua	0219	X3
FA42D244	014W	Yosemite	0220	X3
FA4306D6	038W	San Gorgonio	0219	X3
FA4315A0	038W	Badlands	0220	X3
FA4356AA	038W	Big Bend	0224	X3
FA436330	038W	Petrified Forest	0225	X3
FA437046	038W	Guadalupe Mountains	0226	X3
FA4380C2	038W	Bandelier	0227	X3
FA43A62E	038W	Bridger	0229	X3
FA42C132	009E	Shenandoah	0232	X3

* GOES FIRST TRANSMISSION TIME (GMT)

** GOES TRANSMISSION INTERVAL (X3 = 3 HOUR INTERVAL)

EXECUTE PROGRAM

Execute the Handar DCP communications program "TERM" from the PC computer.

When the "TERM" setup screen (see Figure 4-4) is displayed on the computer screen, press **F2** to switch to the correct baud rate (300 baud).

Connect the serial port of the PC computer to the DCP programming port (see Figure 4-2 for location) using the DCP programming cable. After the connection is complete, the "TERM" programming screen of Figure 4-6 should be displayed on the computer screen.

Initiate the program download by pressing the **F6** key.

The next screen prompt displayed is "LOAD PS PROG->DCP." Press **ENTER** in response to this prompt.

The screen prompt "ENTER NAME OF PROGRAM FILE:" is then displayed. Enter **540ROT.DCP** to program a Handar 540 DCP. To program a Handar 570A DCP, enter **570ROT.DCP**.

While the program is loading, the message "P LOADING PROGRAM" will be displayed. Upon completion of the download, the message "P DONE" will be displayed. The "P" at the beginning of a display message indicates that the DCP is in the "PROGRAM" mode. An "R" at the beginning of a message indicates that the DCP is in the "RUN" mode.

EDIT PARAMETERS

Procedures for editing the site-specific parameters are as follows:

Editing commands (the boldfaced character) used in these procedures are as follows:

- **I** Station ID
- **J** DCP time
- **S** Time remaining before next scan
- **T** Time remaining before next transmission
- **M** Data channel select
- **N** Define Sensor Type
- **K** Program GOES/Radio
- **V** Scroll Down
- **U** Scroll Up

- **$** Forced Scan
- **#** Forced Transmit (GOES Radio)

Enter **I** to edit the station ID. The download program initially assigns ID "FA43F652" to the DCP. The display message will be "P ID FA43F652."

Enter an unused test ID (e.g., **FA43D0BE**). Note that all ID characters are hexadecimal numbers (0-9 and A-F). The letter "O" is not allowed. The display message will be "P ID FA43D0BE."

Enter **K** to program the GOES functions. The display message will be "P GOES PRI XMT MODE 01."

Enter **V** to scroll down to the next prompt, "P 1ST GOES XMT TIME 02:30:00."

Enter the "first transmit time" assigned to the selected station ID. For ID FA43D0BE, the first transmit time is "02:00:00." Enter **020000** (the colons are added by the DCP). The display message will be "P 1ST GOES XMT TIME 02:00:00."

Enter **V** to scroll down to the next prompt, "P PRI XMT INTERVAL 03:00:00." This is the proper transmit interval for all IMPROVE transmissometer sites. Editing is not required.

Enter **V** to scroll down to the next prompt, "P GOES SEC XMT MODE 00." This is the proper secondary transmit mode for all IMPROVE transmissometer sites. Editing is not required.

Enter **J** to set the DCP time and date. The display message will be "P STATION TIME 23:27:45." (The actual time displayed in the message is not important).

All DCP times are Greenwich Mean Time (GMT). Enter the time at the top of the next minute (e.g., if the current GMT time is 14:32:28, enter **14:33:00**) and press **ENTER** at the top of the minute. The display message will be "P STATION TIME 14:33:00."

Enter **V** to scroll down to the next prompt, "P YEAR (XX) 88."

Enter the last 2 digits of the current year (e.g., **94**). The display message will be "P YEAR (XX) 94."

Enter **V** to scroll down to the next prompt, "P DCP JULIAN DATE 326."

Enter the correct Julian date (e.g., for January 28, enter **028**). The display message will be "P DCP JULIAN DATE 028."

Enter **M** to select DCP channel 01. The display message will be "P CHANNEL 01."

Enter **N** to edit the sensor configuration. The display message will be "P01 SENSOR TYPE 10."

Enter **V** to scroll through the sensor configuration until you reach the "start of measurement prompt", "P01 START OF MEAS 23:30:00."

The start of measurement time should be programmed for 30 minutes after the current hour (e.g., if the current time is 17:04:29, enter **17:30:00**). A second prompt asking "CHANGE ALL CHANNELS? (1=Y, 2=N) will be displayed.

Enter **1**, setting the start of measurement time for all channels to 17:30:00. The display message will be "P01 START OF MEAS 17:30:00."

This completes programming of the Handar 540A/570A DCP.

4.4 PRE-FIELD PERFORMANCE TESTING

Pre-field performance testing of the Handar 540A/570A DCP includes laboratory performance testing and a 7-day field test at the Fort Collins Transmissometer Calibration and Test Facility. Laboratory performance testing verifies proper programming and calibration of the DCP. Field testing exposes the DCP to a varying operational environment, testing the ability of the DCP to maintain accurate timing and calibration over a wide range of operating conditions. Document all performance checks and results on the Laboratory Performance Testing Form - Handar 540A/570A DCP (see Figure 4-10).

4.4.1 General Information

RECORD GENERAL INFORMATION	Record the DCP serial number, the site it was received from, and the date it was received. The initials of the technician performing the inspection should also be recorded.
IDENTIFY DCP MODEL	Identify the DCP model (Figure 4-2 shows the front panel layout of each of the three DCP models used by ARS).

4.4.2 Laboratory Performance Testing

Laboratory performance testing repeats the DCP performance and timing checks and the transmission test performed during the post-field inspection and performance checks. It also adds a run mode timing check. Procedures for conducting laboratory performance testing are:

- Perform DCP timing checks as described in Section 4.1.4.
- Perform DCP A/D converter checks as described in Section 4.1.5.
- Perform the DCP transmission test as described in Section 4.1.6.

LABORATORY PERFORMANCE TESTING
HANDAR 540A/570A DCP

DCP S/N: ____________________________
Date: _______________________________
Technician: __________________________

DCP Model: ☐540A1 ☐540A2 ☐570A

DCP TIMING CHECKS

Program in Memory ☐Yes ☐No
DCP ID [I] _____________________
DCP Time [J] __ __ : __ __ : __ __ WWV Time __ __ : __ __ : __ __
DCP Time to Next Scan [S] __ __ : __ __ : __ __
DCP Time to Next Transmit [T] __ __ : __ __ : __ __

DCP A/D CONVERTER CHECKS

Test Input Ch. 1,2,3	DCP Channel # (Output) CH1	CH2	CH3	CH4	CH5	CH10
0.000 Volts	________	________	________	________	________	________
4.950 Volts	________	________	________	________	________	________
Lab AT/RH				________	________	

TRANSMIT TEST

Forced Transmit RF Power Output ______________ Watts

RUN MODE TIMING CHECKS

☐ Primary Channel Select Switches Set to 900
☐ Secondary Channel Select Switches Set to 000
☐ DCP in Run Mode

Assigned ID __________________
Next Scheduled Scan Time __ __ : __ __ : __ __
Next Scheduled Transmit Time __ __ : __ __ : __ __

DCP ID [I] ___________________
DCP Time [J] __ __ : __ __ : __ __
WWV Time __ __ : __ __ : __ __

DCP Time to Next Scan [S] __ __ : __ __ : __ __
WWV Time __ __ : __ __ : __ __
Next Scan Time (WWV Time + Time to Next Scan) __ __ : __ __ : __ __

DCP Time to Next Transmit [T] __ __ : __ __ : __ __
WWV Time __ __ : __ __ : __ __
Next Transmit Time (WWV Time + Time to Next Transmit) __ __ : __ __ : __ __

Figure 4-10. Laboratory Performance Testing Form - Handar 540A/570A DCP.

4.4.3 Run Mode Timing Checks

VERIFY GOES SWITCHES	Verify that the GOES primary channel select switches are set to "900" and the secondary channel select switches set to "000." If the switches are not set to these channels, they must be reset prior to continuing with laboratory testing of the DCP.
RECORD PARAMETERS	Enter **Y** to place the DCP in the "RUN" mode.
	Enter **I** to display the station ID. Verify that the ID displayed is the ID programmed into the DCP.
	At the top of the minute (using GMT as the reference), enter **J** to display the station time. Record GMT and station time. If the station time differs from GMT by more than 2 seconds, reset the station time (see Section 4.3, DCP Programming).
	Enter **S** to obtain the time remaining before the next scan. Record GMT at the time the "S" command was entered and the time remaining as reported by the DCP. Adding the time remaining to the recorded GMT should give the next scheduled scan time (normally set for 30 minutes after the hour).
	Enter **T** to obtain the time remaining before the next transmission. Record GMT at the time the "T" command was entered and the time remaining as reported by the DCP. Adding the time remaining to the recorded GMT should give the next scheduled transmission time (see Table 4-1 for a list of station IDs and their assigned transmission times).

4.4.4 Field Testing of the Handar 540A/570A DCP

INSTALL	Transport the DCP to field test site and install the unit in the DCP transmissometer receiver shelter.
CONNECT TRICKLE LOCATION	Connect the on-site trickle charger to the DCP (see Figure 4-2 for the DCP connector location).
CONNECT ANTENNA	Connect the GOES antenna (mounted on the outside of the receiver shelter and previously aligned) to the DCP RF output connector.
SET GOES SWITCHES	Open the DCP case and set the GOES primary channels selection switches to the channel assigned to the ID of the DCP under test (see Table 4-1).
CONNECT WATTMETER	Connect an RF wattmeter (with a 200-500 mHz, 25-watt power element) between the "RF Output" connector located on the front panel of the DCP and the DCP antenna cable.

Set the power element of the wattmeter for the forward direction.

Monitor the wattmeter reading as the first transmit time approaches. When the transmitter turns on (as indicated by a sharp increase in the wattmeter reading), note the peak power reading in the forward direction. Reverse the direction of the power element and note the peak reading of the reflected power.

The forward direction wattmeter reading should be 10 ± 2 watts. The reflected power reading should be less than two watts.

Disconnect the wattmeter and reconnect the antenna to the DCP.

Place two fresh desiccant packs inside the DCP. Close the DCP and tighten all latches to ensure a tight seal.

The transmitted data are reviewed daily, verifying that the transmit time, frequency deviation, and power level all meet factory specifications (Refer to TI 4300-4000, *Data Collection via DCP (IMPROVE Protocol)*).

If the transmitted data review indicates timing, frequency deviation, or power related problems, the field test should be terminated and the DCP returned to the laboratory. The instrument technician will then coordinate with Handar to arrange for repair and/or recalibration of the DCP.

If the DCP operates within factory specifications throughout the seven day test period, the DCP is returned to the laboratory and turned off until it is needed in the IMPROVE transmissometer network.

All field test data printouts are archived with the DCP service records as described in Section 4.5.

4.5 ARCHIVING HANDAR 540A/570A DCP SERVICE RECORDS

Service records for Handar DCPs are maintained by the instrument technician and archived by DCP serial number in three-ring notebooks located in the ARS instrumentation laboratory.

5.0 REFERENCES

Handar, Inc., 1988, 570A Data Acquisition System Operating and Service Manual, March.

Handar, Inc., 1982, Operating and Service Manual for 540A Multiple Access Data Acquisition System, 560A Hydrologic Data Collection System, and 545A Programming Set, June.

APPENDIX A

HANDAR 540A DCP CONFIGURATION PROGRAM - 540ROT.DCP

P ID	FA43D0BE
P STATION TIME	15:47:38
P YEAR (XX)	94
P DCP JULIAN DATE	055
P GOES PRI XMT MODE	01
P 1ST GOES XMT TIME	02:00:00
P PRI XMT INTERVAL	03:00:00
P GOES SEC XMT MODE	00
P TEL #:AREA CODE	1-303
P TEL #:LOCAL	224-9300
P MODEM XMT FORMAT	00
P 1ST DIAL TIME	00:00:00
P DIAL INTERVAL	00:00:00
P TEL EMG XMIT 1=0N	00
P AUTO DUMP? 1=Y 0=N	00
P CHANNEL NO.	01
P01 SENSOR TYPE	10
P01 CARD SLOT #	06
P01 SENSOR INPUT ADRS	6
P01 SENSOR PWR ADRS	8
P01 SENSOR PWR ADV	00:00:02
P01 *FULL SCALE	1000
P01 ZERO SCALE	0000
P01 MEAS INTERVAL	01:00:00
P01 START OF MEAS	16:30:00
P01 LEVEL 1 MEAS TYPE	001
P01 XMIT 2 OR 3 BYTES?	03
P01 HIGH LIMIT	NO LIMIT
P01 LOW LIMIT	NO LIMIT
P01 HIGH DIFF LIMIT	NO LIMIT
P01 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	02
P02 SENSOR TYPE	10
P02 CARD SLOT #	06
P02 SENSOR INPUT ADRS	9
P02 SENSOR PWR ADRS	8
P02 SENSOR PWR ADV	00:00:02
P02 *FULL SCALE	001
P02 ZERO SCALE	000
P02 MEAS INTERVAL	01:00:00
P02 START OF MEAS	16:30:00
P02 LEVEL 1 MEAS TYPE	001
P02 XMIT 2 OR 3 BYTES?	03
P02 HIGH LIMIT	NO LIMIT
P02 LOW LIMIT	NO LIMIT
P02 HIGH DIFF LIMIT	NO LIMIT
P02 LOW DIFF LIMIT	NO LIMIT

P CHANNEL NO.	03
P03 SENSOR TYPE	10
P03 CARD SLOT #	06
P03 SENSOR INPUT ADRS	8
P03 SENSOR PWR ADRS	8
P03 SENSOR PWR ADV	00:00:02
P03 *FULL SCALE	500
P03 ZERO SCALE	000
P03 MEAS INTERVAL	01:00:00
P03 START OF MEAS	16:30:00
P03 LEVEL 1 MEAS TYPE	001
P03 XMIT 2 OR 3 BYTES?	03
P03 HIGH LIMIT	NO LIMIT
P03 LOW LIMIT	NO LIMIT
P03 HIGH DIFF LIMIT	NO LIMIT
P03 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	04
P04 SENSOR TYPE	10
P04 CARD SLOT #	06
P04 SENSOR INPUT ADRS	C
P04 SENSOR PWR ADRS	8
P04 SENSOR PWR ADV	00:00:02
P04 *FULL SCALE	0978
P04 ZERO SCALE	0081
P04 MEAS INTERVAL	01:00:00
P04 START OF MEAS	16:30:00
P04 LEVEL 1 MEAS TYPE	001
P04 XMIT 2 OR 3 BYTES?	03
P04 HIGH LIMIT	NO LIMIT
P04 LOW LIMIT	NO LIMIT
P04 HIGH DIFF LIMIT	NO LIMIT
P04 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	05
P05 SENSOR TYPE	04
P05 CARD SLOT #	06
P05 SENSOR PWR ADV	00:00:02
P05 HUMIDITY CHAN (1,2)	01
P05 *FULL SCALE	500
P05 ZERO SCALE	000
P05 MEAS INTERVAL	01:00:00
P05 START OF MEAS	16:30:00
P05 LEVEL 1 MEAS TYPE	001
P05 XMIT 2 OR 3 BYTES?	03
P05 HIGH LIMIT	NO LIMIT
P05 LOW LIMIT	NO LIMIT
P05 HIGH DIFF LIMIT	NO LIMIT
P05 LOW DIFF LIMIT	NO LIMIT

P CHANNEL NO.	06
P06 SENSOR TYPE	10
P06 CARD SLOT #	06
P06 SENSOR INPUT ADRS	5
P06 SENSOR PWR ADRS	8
P06 SENSOR PWR ADV	00:00:02
P06 *FULL SCALE	000
P06 ZERO SCALE	000
P06 MEAS INTERVAL	01:00:00
P06 START OF MEAS	16:30:00
P06 LEVEL 1 MEAS TYPE	001
P06 XMIT 2 OR 3 BYTES?	03
P06 HIGH LIMIT	NO LIMIT
P06 LOW LIMIT	NO LIMIT
P06 HIGH DIFF LIMIT	NO LIMIT
P06 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	07
P07 SENSOR TYPE	10
P07 CARD SLOT #	06
P07 SENSOR INPUT ADRS	D
P07 SENSOR PWR ADRS	8
P07 SENSOR PWR ADV	00:00:02
P07 *FULL SCALE	000
P07 ZERO SCALE	000
P07 MEAS INTERVAL	01:00:00
P07 START OF MEAS	16:30:00
P07 LEVEL 1 MEAS TYPE	001
P07 XMIT 2 OR 3 BYTES?	03
P07 HIGH LIMIT	NO LIMIT
P07 LOW LIMIT	NO LIMIT
P07 HIGH DIFF LIMIT	NO LIMIT
P07 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	08
P08 SENSOR TYPE	10
P08 CARD SLOT #	06
P08 SENSOR INPUT ADRS	A
P08 SENSOR PWR ADRS	8
P08 SENSOR PWR ADV	00:00:02
P08 *FULL SCALE	000
P08 ZERO SCALE	000
P08 MEAS INTERVAL	01:00:00
P08 START OF MEAS	16:30:00
P08 LEVEL 1 MEAS TYPE	001
P08 XMIT 2 OR 3 BYTES?	03
P08 HIGH LIMIT	NO LIMIT
P08 LOW LIMIT	NO LIMIT
P08 HIGH DIFF LIMIT	NO LIMIT

P08 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	09
P09 SENSOR TYPE	10
P09 CARD SLOT #	06
P09 SENSOR INPUT ADRS	8
P09 SENSOR PWR ADRS	8
P09 SENSOR PWR ADV	00:00:02
P09 *FULL SCALE	00.0
P09 ZERO SCALE	00.0
P09 MEAS INTERVAL	01:00:00
P09 START OF MEAS	16:30:00
P09 LEVEL 1 MEAS TYPE	001
P09 XMIT 2 OR 3 BYTES?	03
P09 HIGH LIMIT	NO LIMIT
P09 LOW LIMIT	NO LIMIT
P09 HIGH DIFF LIMIT	NO LIMIT
P09 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	10
P10 SENSOR TYPE	12
P10 MEAS INTERVAL	01:00:00
P10 START OF MEAS	16:30:00
P10 LEVEL 1 MEAS TYPE	001
P10 XMIT 2 OR 3 BYTES?	03
P10 HIGH LIMIT	NO LIMIT
P10 LOW LIMIT	NO LIMIT
P10 HIGH DIFF LIMIT	NO LIMIT
P10 LOW DIFF LIMIT	NO LIMIT

APPENDIX B

HANDAR 570A DCP CONFIGURATION PROGRAM - 570TROT.DCP

P ID	FA43D0BE
P STATION TIME	22:46:25
P YEAR (XX)	94
P DCP JULIAN DATE	047
P GOES PRI XMT MODE	01
P 1ST GOES XMT TIME	02:00:00
P PRI XMT INTERVAL	03:00:00
P GOES SEC XMT MODE	00
P TEL #:AREA CODE	0-000
P TEL #:LOCAL	000-0000
P MODEM XMT FORMAT	00
P 1ST DIAL TIME	00:00:00
P DIAL INTERVAL	00:00:00
P TEL EMG XMIT 1=0N	00
P AUTO DUMP? 1=Y 0=N	00
P VOICE OUTPUT MODE	00
P TOUCH TONE PASSWD	0
P CHANNEL NO.	01
P01 SENSOR TYPE	10
P01 SENSOR NAME TAG	10
P01 CARD SLOT #	01
P01 ADC INPUT MODE	2
P01 ADC INPUT NUMBER	08
P01 ADC SCALE (5.0E-X)	0
P01 ADC OUTPUT NUMBER	0
P01 SENSOR PWR ADV	00:00:02
P01 *FULL SCALE	1000
P01 ZERO SCALE	0000
P01 MEAS INTERVAL	01:00:00
P01 START OF MEAS	17:30:00
P01 LEVEL 1 MEAS TYPE	001
P01 XMIT 2 OR 3 BYTES?	03
P01 HIGH LIMIT	NO LIMIT
P01 LOW LIMIT	NO LIMIT
P01 HIGH DIFF LIMIT	NO LIMIT
P01 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	02
P02 SENSOR TYPE	10
P02 SENSOR NAME TAG	10
P02 CARD SLOT #	01
P02 ADC INPUT MODE	1
P02 ADC INPUT NUMBER	06
P02 ADC SCALE (5.0E-X)	0
P02 ADC OUTPUT NUMBER	0
P02 SENSOR PWR ADV	00:00:02
P02 *FULL SCALE	001
P02 ZERO SCALE	000

P02 MEAS INTERVAL	01:00:00
P02 START OF MEAS	17:30:00
P02 LEVEL 1 MEAS TYPE	001
P02 XMIT 2 OR 3 BYTES?	03
P02 HIGH LIMIT	NO LIMIT
P02 LOW LIMIT	NO LIMIT
P02 HIGH DIFF LIMIT	NO LIMIT
P02 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	03
P03 SENSOR TYPE	10
P03 SENSOR NAME TAG	10
P03 CARD SLOT #	01
P03 ADC INPUT MODE	1
P03 ADC INPUT NUMBER	14
P03 ADC SCALE (5.0E-X)	0
P03 ADC OUTPUT NUMBER	0
P03 SENSOR PWR ADV	00:00:02
P03 *FULL SCALE	999
P03 ZERO SCALE	000
P03 MEAS INTERVAL	01:00:00
P03 START OF MEAS	17:30:00
P03 LEVEL 1 MEAS TYPE	001
P03 XMIT 2 OR 3 BYTES?	03
P03 HIGH LIMIT	NO LIMIT
P03 LOW LIMIT	NO LIMIT
P03 HIGH DIFF LIMIT	NO LIMIT
P03 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	04
P04 SENSOR TYPE	10
P04 SENSOR NAME TAG	10
P04 CARD SLOT #	01
P04 ADC INPUT MODE	1
P04 ADC INPUT NUMBER	04
P04 ADC SCALE (5.0E-X)	0
P04 ADC OUTPUT NUMBER	2
P04 SENSOR PWR ADV	00:00:02
P04 *FULL SCALE	0978
P04 ZERO SCALE	0078
P04 MEAS INTERVAL	01:00:00
P04 START OF MEAS	17:30:00
P04 LEVEL 1 MEAS TYPE	001
P04 XMIT 2 OR 3 BYTES?	03
P04 HIGH LIMIT	NO LIMIT
P04 LOW LIMIT	NO LIMIT
P04 HIGH DIFF LIMIT	NO LIMIT
P04 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	05

P05 SENSOR TYPE	10
P05 SENSOR NAME TAG	10
P05 CARD SLOT #	01
P05 ADC INPUT MODE	1
P05 ADC INPUT NUMBER	12
P05 ADC SCALE (5.0E-X)	0
P05 ADC OUTPUT NUMBER	2
P05 SENSOR PWR ADV	00:00:02
P05 *FULL SCALE	500
P05 ZERO SCALE	000
P05 MEAS INTERVAL	01:00:00
P05 START OF MEAS	17:30:00
P05 LEVEL 1 MEAS TYPE	001
P05 XMIT 2 OR 3 BYTES?	03
P05 HIGH LIMIT	NO LIMIT
P05 LOW LIMIT	NO LIMIT
P05 HIGH DIFF LIMIT	NO LIMIT
P05 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	06
P06 SENSOR TYPE	10
P06 SENSOR NAME TAG	10
P06 CARD SLOT #	01
P06 ADC INPUT MODE	1
P06 ADC INPUT NUMBER	05
P06 ADC SCALE (5.0E-X)	0
P06 ADC OUTPUT NUMBER	0
P06 SENSOR PWR ADV	00:00:02
P06 *FULL SCALE	000
P06 ZERO SCALE	000
P06 MEAS INTERVAL	01:00:00
P06 START OF MEAS	17:30:00
P06 LEVEL 1 MEAS TYPE	001
P06 XMIT 2 OR 3 BYTES?	03
P06 HIGH LIMIT	NO LIMIT
P06 LOW LIMIT	NO LIMIT
P06 HIGH DIFF LIMIT	NO LIMIT
P06 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	07
P07 SENSOR TYPE	10
P07 SENSOR NAME TAG	10
P07 CARD SLOT #	01
P07 ADC INPUT MODE	1
P07 ADC INPUT NUMBER	13
P07 ADC SCALE (5.0E-X)	0
P07 ADC OUTPUT NUMBER	0
P07 SENSOR PWR ADV	00:00:02
P07 *FULL SCALE	000

P07 ZERO SCALE	000
P07 MEAS INTERVAL	01:00:00
P07 START OF MEAS	17:30:00
P07 LEVEL 1 MEAS TYPE	001
P07 XMIT 2 OR 3 BYTES?	03
P07 HIGH LIMIT	NO LIMIT
P07 LOW LIMIT	NO LIMIT
P07 HIGH DIFF LIMIT	NO LIMIT
P07 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	08
P08 SENSOR TYPE	10
P08 SENSOR NAME TAG	10
P08 CARD SLOT #	01
P08 ADC INPUT MODE	1
P08 ADC INPUT NUMBER	07
P08 ADC SCALE (5.0E-X)	0
P08 ADC OUTPUT NUMBER	0
P08 SENSOR PWR ADV	00:00:02
P08 *FULL SCALE	000
P08 ZERO SCALE	000
P08 MEAS INTERVAL	01:00:00
P08 START OF MEAS	17:30:00
P08 LEVEL 1 MEAS TYPE	001
P08 XMIT 2 OR 3 BYTES?	03
P08 HIGH LIMIT	NO LIMIT
P08 LOW LIMIT	NO LIMIT
P08 HIGH DIFF LIMIT	NO LIMIT
P08 LOW DIFF LIMIT	NO LIMIT
P CHANNEL NO.	09
P09 SENSOR TYPE	10
P09 SENSOR NAME TAG	10
P09 CARD SLOT #	01
P09 ADC INPUT MODE	1
P09 ADC INPUT NUMBER	15
P09 ADC SCALE (5.0E-X)	0
P09 ADC OUTPUT NUMBER	0
P09 SENSOR PWR ADV	00:00:02
P09 *FULL SCALE	00.0
P09 ZERO SCALE	00.0
P09 MEAS INTERVAL	01:00:00
P09 START OF MEAS	17:30:00
P09 LEVEL 1 MEAS TYPE	001
P09 XMIT 2 OR 3 BYTES?	03
P09 HIGH LIMIT	NO LIMIT
P09 LOW LIMIT	NO LIMIT
P09 HIGH DIFF LIMIT	NO LIMIT
P09 LOW DIFF LIMIT	NO LIMIT

P CHANNEL NO.	10
P10 SENSOR TYPE	12
P10 SENSOR NAME TAG	12
P10 MEAS INTERVAL	01:00:00
P10 START OF MEAS	17:30:00
P10 LEVEL 1 MEAS TYPE	001
P10 XMIT 2 OR 3 BYTES?	03
P10 HIGH LIMIT	NO LIMIT
P10 LOW LIMIT	NO LIMIT
P10 HIGH DIFF LIMIT	NO LIMIT
P10 LOW DIFF LIMIT	NO LIMIT

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
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AUTHORIZATIONS		
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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) outlines collection of optical visibility monitoring data from sites operated according to IMPROVE Protocol. Optical monitoring sites include those equipped with an Optec LPV transmissometer and/or Optec NGN nephelometer.

The IMPROVE Program has partitioned visibility-related characteristics and measurements into three groups: optical, scene, and aerosol. This SOP pertains to the optical group and encompasses the following:

- Optical properties pertaining to the ability of the atmosphere to scatter or absorb light passing through it
- Physical properties of the atmosphere described by the atmospheric extinction coefficient (b_{ext}), absorption coefficient (b_{abs}), scattering coefficient (b_{scat}), and scattering phase function, an angular dependence of the scattering
- Optical characteristics integrating the effects of atmospheric aerosols and gases
- Optical extinction measurements made with transmissometers
- Optical scattering measurements made with nephelometers

Data are generally logged on-site by one of four data logging approaches:

- Satellite data collection platforms (DCPs) (Handar 540/570 or Synergetics)
- Campbell Scientific 21XL dataloggers
- Telephone modems
- Primeline strip chart recorders

This SOP serves as a guide to assure high quality data collection from transmissometer and nephelometer stations operated according to IMPROVE Protocol by:

- Assuring complete, error-free data downloads from Wallops Island or directly from the individual stations via telephone modem.
- Assuring complete, error-free data downloads from sites with Campbell Scientific data storage modules.
- Reducing data from strip chart recorders at transmissometer sites.
- Processing data to reformat raw, downloaded data to Level-A validation.
- Reviewing data and examining error files for details regarding monitoring system performance, datalogger problems, or data acquisition problems.

Because most stations are remote, daily data review is critical to the identification and resolution of field problems.

At sites with a DCP or Campbell Scientific datalogger and telephone modem, data are collected daily. At sites with a Campbell Scientific datalogger and storage module, or at sites where back-up strip chart recorders must be used, data are collected at approximately two-week intervals.

Separate technical instructions (TIs) are developed for the following cases:

- TI 4300-4000 *Data Collection via DCP (IMPROVE Protocol)*
- TI 4300-4002 *Nephelometer Data Collection via Telephone Modem (IMPROVE Protocol)*
- TI 4300-4004 *Nephelometer Data Compilation and Review of DCP-Collected Data (IMPROVE Protocol)*
- TI 4300-4006 *Nephelometer Data Collection via Campbell Scientific Data Storage Module (IMPROVE Protocol)*
- TI 4300-4023 *Transmissometer Daily Compilation and Review of DCP-Collected Data (IMPROVE Protocol)*
- TI 4300-4025 *Transmissometer Data Collection via Strip Chart Recorder*

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Review data collection procedures with the data coordinator to identify and correct problems.
- Review editing of instrument constants files with the data coordinator.
- Coordinate with the NESDIS for allocation of DCP assignments.

2.2 DATA COORDINATOR

The data coordinator shall:

- Update all constants files pertaining to data collection and review with the project manager.
- Set up and initiate the automatic data collection program(s).
- Check the status of the automatic data collection and review data daily to assure the integrity of the monitoring systems and to achieve complete, error-free data collection.
- Perform periodic data collection via data storage module or strip chart reduction for sites without DCP or modem communication.

- Provide technical support to the site operator via telephone.
- Enter any information relating to the collection of the data and operation of the specific monitoring system into the site-specific Quality Assurance Database.
- Review Level-A files with the project manager to identify instrument problems.
- Ship supplies, tools, and replacement instrumentation to the site operator.
- Digitize and convert strip chart recorder data into transmissometer format.

2.3 FIELD SPECIALIST

The field specialist shall:

- Train the site operator in strip chart recorder operation and maintenance.
- Provide technical support to the site operator via telephone.

2.4 SITE OPERATOR

The site operator shall:

- Operate and maintain strip chart recorders.
- Document strip chart recorder operation.
- Report instrument collection inconsistencies to the data coordinator or field specialist.

3.0 REQUIRED EQUIPMENT AND MATERIALS

All data collection occurs on IBM-PC compatible systems. Refer to the individual TIs for the monitoring system-specific computer system requirements. Required computer system components are as follows:

- IBM-PC compatible 386/486 computer system with VGA and 80 megabyte hard disk
- Internal or external Hayes compatible modem configured for COM port #2
- Microsoft Windows 3.0/3.1
- Software for collection DCP data via Wallops Island
- Software for processing of optical data collected via DCP
- Software for telephone modem collection
- Campbell Scientific software for processing optical data:
  - TELCOM Version 1.0 or later

- SPLIT Version 1.0 or later
- SMCOM Version 1.0 or later
- TERM Version 1.0 or later

- Campbell Scientific SC532 storage module interface
- NGN_PULL software Version 3.0 or later (ARS)
- Jandel Scientific Sigma Scan software for digitizing strip charts
- Jandel Scientific digitizing table

Information on the Campbell Scientific software is detailed in the *Campbell Scientific PC208 Datalogger Support Software Instruction Manual*.

4.0 METHODS

This section includes two (2) major subsections:

4.1 Optical Monitoring Station Configurations
4.2 Collection of Optical Monitoring Data

These subsections describe the station configurations and data collection methods for each configuration. Collection of optical monitoring data is dependent on the configuration of individual sites. Transmissometer and nephelometer sites are generally configured differently.

4.1 OPTICAL MONITORING STATION CONFIGURATIONS

Optical monitoring stations are configured based on the following:

- Transmissometer stations are generally configured with a DCP and strip chart recorder.
- Nephelometer stations are generally configured with a Campbell Scientific datalogger, telephone modem, storage module, or optionally, a DCP.

4.1.1 <u>Transmissometer Stations</u>

Transmissometers measure the ability of the atmosphere to transmit light. These measured light transmission properties can be represented in terms of the atmospheric extinction coefficient (b_{ext}).

IMPROVE transmissometer sites generally include:

- A transmitter station with shelter, transmitter telescope, transmitter control box, and battery-backed power supply.
- A receiver station with shelter, receiver telescope, receiver computer, battery-backed power supply.

- A data collection platform (DCP).
- An optional strip chart recorder.
- A collocated air temperature and relative humidity sensor (naturally aspirated).
- A solar powered operation (at some sites).

The following data are collected via DCP from transmissometer sites operated according to IMPROVE Protocol:

- Ten-minute average raw transmissometer transmission values that are later converted to atmospheric extinction coefficient.
- Standard deviation of the 10 one-minute raw transmission values that make up the 10-minute average transmission value.
- Hourly, single reading ambient air temperature and relative humidity.

Strip charts serve as the backup logger at transmissometer sites. Strip charts are only used in the event of DCP failure. The strip chart recorder from transmissometer sites operated according to IMPROVE Protocol collects 10-minute average raw transmissometer transmission values that are later converted to atmospheric extinction coefficient.

4.1.2 Nephelometer Stations

Nephelometers measure the ability of the atmosphere to scatter light. These measured light scattering properties can be represented in terms of the atmospheric scattering coefficient (b_{scat}).

IMPROVE nephelometer sites generally include:

- An NGN-2 nephelometer mounted on a three-meter tower along with datalogger and power supply support system.
- A Campbell Scientific 21XL datalogger.
- A Campbell Scientific storage module.
- An optional telephone modem.
- An optional DCP.
- A collocated air temperature and relative humidity sensor (force aspirated).
- A solar powered operation (at some sites).

The following data are collected via telephone modem and storage module from nephelometer sites operated according to IMPROVE protocol:

- Five-minute nephelometer serial data stream

- Five-minute nephelometer analog channels A1 and A2
- Five-minute ambient air temperature and relative humidity
- Hourly codes summarizing the past hour's operation of the nephelometer and support system.

The following data are collected via DCP from nephelometer sites operated according to IMPROVE Protocol:

- Ten-minute nephelometer analog channels A1 and A2
- Hourly codes summarizing the past hour's operation of the nephelometer and support system.
- Last clean air and span calibrations
- Hourly, single-reading ambient air temperature and relative humidity

4.2 COLLECTION OF OPTICAL MONITORING DATA

The method used to collect optical monitoring data depends on the type of site (transmissometer or nephelometer) and the site-specific configuration (telephone modem, storage module, DCP or strip chart). The following subsections describe data collection procedures for the above listed station configurations.

4.2.1 Collection of Transmissometer Data via DCP

Specific transmissometer data collection procedures are detailed in TI 4300-4000, *Data Collection via DCP (IMPROVE Protocol)*. Collection of transmissometer data via DCP includes:

- Updating the current list of sites in the site information file.
- Updating the next time to download data in the Wallops information file.
- Configuring the computer used for automatic data acquisition that downloads the data from Wallops the following day.
- Reviewing all downloaded data file for communication errors or indications of monitoring, logging and data collection problems.
- Initiating data collection programs if automatic data collection failed.
- Executing the STRIP_T program which removes invalid characters and reformats the raw file.
- Executing the APPEND_T program to add the raw data to site-specific Level-A files.
- Resolving identified system inconsistencies according to TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

4.2.2 Collection of Transmissometer Data via Strip Chart Recorder

Strip chart recorder data are only used as a backup logging method at sites where DCP system failures occur, and are only used until the malfunctioning DCP can be repaired or replaced. Specific procedures are detailed in TI 4300-4025, *Transmissometer Data Collection via Strip Chart Recorder*. Collection of transmissometer data via strip chart recorder includes the following:

- Obtaining strip charts.
- Digitizing the strip chart trace.
- Scaling the digitized values to yield raw transmission values.
- Transferring raw transmission data from the strip chart file into the site-specific Level-A file.
- Changing the validity code in the site-specific Level-A file to reflect the use of an alternate datalogger.

4.2.3 Collection of Nephelometer Data via Telephone Modem

Collection of nephelometer data via telephone modem from sites configured with a Campbell Scientific datalogger is handled by the NGN_PULL software. Specific procedures are detailed in TI 4300-4002, *Nephelometer Data Collection via Telephone Modem (IMPROVE Protocol)*. Collection of nephelometer data via modem includes the following:

- Updating the current list of sites.
- Updating the next time to download data.
- Initiating the automatic download timer.
- Polling each telephone modem station daily using the Campbell Scientific TELCOM program for all data since the last download.
- Dividing each downloaded data file into three parts using the Campbell Scientific SPLIT program:
    - Nephelometer serial data, ambient temperature, and relative humidity
    - Nephelometer analog data, ambient temperature, and relative humidity
    - Hourly nephelometer status code and support system status code
- Reformatting and appending each site's nephelometer serial data to site-specific Level-A plottable data files.
- Creating a daily nephelometer log file that contains a summary of the performance of all of the sites downloaded.

- Resolving identified system inconsistencies according to TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*.

4.2.4 Collection of Nephelometer Data via DCP

Collection of nephelometer data via DCP is handled by the NGN_PULL software. Specific procedures are detailed in TI 4300-4004, *Nephelometer Data Compilation and Review of DCP-Collected Data (IMPROVE Protocol)*. Collection of nephelometer data via DCP includes the following:

- Updating the current list of sites.
- Extracting each site's data from the stripped daily download file into site-specific daily data files compatible with data obtained via telephone modem.
- Dividing each reformatted data file into three parts using the Campbell Scientific SPLIT program:
  - Nephelometer analog data, ambient temperature, and relative humidity
  - Hourly nephelometer status code and support system status code
- Reformatting and appending each site's nephelometer analog data to site-specific Level-A plottable data files.
- Creating a daily nephelometer log file that contains a summary of the performance of all of the sites downloaded.
- Resolving identified system inconsistencies according to TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*.

4.2.5 Collection of Nephelometer Data via Campbell Scientific Storage Module

Collection of nephelometer data via Campbell Scientific storage module is handled by the NGN_PULL software. Specific procedures are detailed in TI 4300-4006, *Nephelometer Data Collection via Campbell Scientific Data Storage Module (IMPROVE Protocol)*. Collection of nephelometer data via storage module includes the following:

- Updating the current list of sites.
- Downloading data from the storage module using the Campbell Scientific SMCOM program into site-specific files compatible with data obtained via telephone modem.
- Dividing each downloaded data file into three parts using the Campbell Scientific SPLIT program:
  - Nephelometer serial data, ambient temperature, and relative humidity
  - Nephelometer analog data, ambient temperature, and relative humidity
  - Hourly nephelometer status code and support system status code

- Reformatting and appending each site's nephelometer serial data to site-specific plottable data files.

- Creating a nephelometer log file that contains a summary of the performance of all of the sites downloaded.

- Resolving identified system inconsistencies according to TI 4100-3100.

5.0 REFERENCES

Campbell Scientific, Inc., 1989, Campbell Scientific PC208 Datalogger Support Software Instruction Manual, February.

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OTHER		

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LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the collection of data logged by data collection platforms (DCPs) at transmissometer, nephelometer, and meteorological sites operated according to IMPROVE Protocol. The purpose of this TI is to assure quality data capture and minimize data loss by:

- Monitoring DCP operating parameters, including: transmission time, DCP battery voltage, signal strength, and transmission frequency deviation.
- Identifying and resolving problems affecting transmissometer and nephelometer systems, meteorological sensors, data acquisition and control systems, and support equipment.

This TI, as referenced from Standard Operating Procedure (SOP) 4300, *Collection of Optical Monitoring Data (IMPROVE Protocol)*, specifically describes:

- General information about data collection via DCP and data acquisition via the National Environmental Satellite Data and Information Service (NESDIS) downlink facility in Camp Springs, Maryland, via the satellite downlink station at Wallops Island, Virginia.
- Automatic and manual data acquisition procedures.
- Daily data handling of DCP data.
- Verification of DCP transmission parameters.
- Procedures for updating the NESDIS Platform Description Tables (PDTs).

Troubleshooting procedures for DCPs are described in TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Coordinate with NESDIS for the allocation of DCP assignments for data collection.
- Review data acquired via DCP to detect and resolve problems.

2.2 DATA COORDINATOR

The data coordinator shall:

- Verify that automatic data collection via DCP is successful and perform manual data collection if unsuccessful.
- Review DCP-transmitted data to determine if the DCP and monitoring equipment are functioning properly.

- Provide technical support to the site operator via telephone to assure high quality data capture from the DCP and monitoring equipment.

- Update NESDIS DCP platform description tables (PDTs) via telephone modem.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Equipment and materials generally required for data collection via DCP includes the following:

- IBM-PC compatible 386/486 computer system with VGA and 80 megabyte hard disk

- Internal or external Hayes compatible modem configured for COM port #2

- Crosstalk-4 PC communications software

- WALLOPS4 PC interface software (ARS)

- User Interface Manual (UIM) for the Data Collection System Automatic Processing System (DAPS), Version 1.1

- Wallops Island log book

- Julian calendar

- Plain ASCII text editor such as WordStar

4.0 METHODS

This section includes six (6) major subsections:

4.1 General Information
4.2 Automatic Data Collection
4.3 Manual Data Collection
4.4 DCP Transmission Quality Check
4.5 Daily DCP Data Handling
4.6 Updating NESDIS Platform Description Tables (PDTs)

4.1 GENERAL INFORMATION

Data logged on data collection platforms (DCPs) are processed by several entities before being available for downloading via modem. Monitoring stations with DCPs undergo the following data downloading sequence:

- The DCP logs transmissometer, nephelometer, and/or meteorological data at pre-programmed intervals.

- At three-hour intervals, the DCP transmits the past three hours' data and its internal battery voltage to the GOES satellite.

- The GOES satellite retransmits the data to the NOAA/NESDIS downlink facility at Wallops Island, Virginia.

- The data are made available via the dissemination facility at Camp Springs, Maryland.

- The data are downloaded via telephone modem to ARS.

4.1.1 GOES Satellite System

The following general information summarizes how satellite data collection works:

SATELLITE USE	Use of the Geostationary Orbiting Earth Satellite (GOES) is free to government agencies. Authorization and operation to use the satellite system is directed by the National Environmental Satellite Data and Information Service (NESDIS), a branch of the National Oceanic and Atmospheric Administration (NOAA).
DCP ASSIGNMENTS	NESDIS assigns each DCP a one-minute data transmit time slot every three hours and a unique DCP identification code. Platform Description Tables (PDTs) describe the location and other operational parameters of each DCP. The PDTs must be updated via modem to reflect the status of all operational DCPs.
SATELLITE SYSTEM CAPACITY	Relay of data from DCPs to the downlink facility is a minor portion of the satellite's job. Its primary function is to provide weather-related data and images to aid in weather forecasting. Each satellite is capable of utilizing 233 frequencies for a total capacity of over 12,000 DCPs per hour. The data transmission rate is 100 baud (bits per second). The majority of the DCPs in use throughout the United States help support early warning flood monitoring systems.

4.1.2 Data Collection Platforms (DCPs)

DCPs manufactured by Handar and Synergetics are used at IMPROVE optical monitoring sites. Transmissometer sites are generally configured with Handar DCPs and nephelometer sites are generally configured with Synergetics DCPs. Both types of DCPs have the following features:

- Low power, programmable, microprocessor based system

- Analog sensor inputs

- Real-time clock

- GOES compatible radio transmitter

The dissemination facility makes the following data available via telephone modem a short time after the DCP transmits its data:

- Data logged by the DCP
- Transmission date and time
- DCP signal strength and deviation from the specified frequency
- Quality of the DCP transmission

DCP transmission parameters are used to evaluate the performance of the DCP and to resolve DCP-related problems quickly.

4.2 AUTOMATIC DATA COLLECTION

Automatic data collection via DCP includes the following steps:

- Log onto the ARS_NET2 network at a designated DCP data collection computer.
- Type **LOGIN BATCH**. Enter **OH** for project code and **2** (server number for an IMPROVE2 auto pull job).
- Update the DCP data collection identification file "WALDCP.DAT."
- Check the date and time of the next automatic batch job and change if necessary.
- Start the batch software.
- Verify the success of the data collection.

The following detailed procedures describe automatic data collection of DCP data:

LOG ONTO NETWORK

Log onto ARS_NET2 on the data handling computer using your assigned user name and password.

UPDATE THE "WALDCP.DAT" FILE

The "WALDCP.DAT" file includes DCP and site-specific information required to download data via modem. The file includes:

- Site abbreviation
- DCP identification number
- DCP transmission time
- DCP transmission period

An example "WALDCP.DAT" file is provided as Figure 4-1.

```
Site|Site_id | Ch.|Time|Interval

ACAD,FA42914E,009E,0227,X3
BADL,FA4315A0,038W,0220,X3
BAND,FA4380C2,038W,0227,X3
BIBE,FA4356AA,038W,0224,X3
BRID,FA43A62E,038W,0229,X3
CANY,FA44F466,014W,0218,X3
CHIR,FA450618,014W,0219,X3
GRBA,FA44E710,014W,0217,X3
```

Format:
Site Abbrv, DCP Iden, DCP Channel and Satellite, Transmit Time and Interval

Figure 4-1. Example "WALDCP.DAT" DCP Definition File for WALLOPS4 Software.

Update the "WALDCP.DAT" file to include all operational DCPs, using any plain ASCII editor such as WordStar. The WordStar command is **WS F:\USERS\WALLOPS\WALDCP.DAT**.

CHECK THE BATCH JOB DATE AND TIME

The batch software runs the data collection software at a predetermined date and time. The list of programs the batch software is scheduled to run is included in the batch queue. The batch queue may be edited to add or delete scheduled batch jobs. The following procedures detail how to edit the batch queue:

- To examine the batch queue enter **BATCH #Q**.
- To delete a job in the batch queue enter **BATCH #D @XXXX**, where "XXXX" is the number of the batch job.
- To add a new batch job for DCP data collection enter **F:\USERS\WALLOPS\NEWBATCH HH:MM NN/DD/YY**, where "HH" is the hour, "MM" is the minute, "NN" is the month, "DD" is the day, and "YY" is the year the batch job is next scheduled to run.

START THE BATCH SOFTWARE

Start the automatic batch software by entering **LOGIN BATCH**.

The result of a successful batch run is a file with the name "GALYYDDD.DAT" where "YY" is the year and "DDD" is the Julian day.

EXIT THE BATCH SOFTWARE

The batch software must be running to perform automatic data collection. To exit the PS-BATCH software enter **X** at the PS BATCH prompt.

4.3 MANUAL DATA COLLECTION

Data may be collected manually via telephone modem from the data dissemination facility as follows:

- Log onto the network.
- Run the WALLOPS4 software.
- Enter the site, DCP identification, date, and time at the WALLOPS4 software prompts.

The following procedures detail manual data collection of DCP data:

LOG ONTO NETWORK

Log onto the ARS_NET2 network on the data collection computer using your assigned user name and password.

START THE WALLOPS4 SOFTWARE

The WALLOPS4 software performs all functions of the user interface for manual data collection. To start the WALLOPS4 software, enter **WALLOPS4** at the DOS prompt. Choose one of the following available download options (detailed in Figure 4-2):

- **S** Download one site.
- **D** Download all sites.
- **T** Download all sites at specific beginning and ending time interval.

ENTER THE FILE NAME

If the **D** or **T** option is chosen, enter the file name for the manual data pull using the "GALYYDDD.DAT" format where "YY" is the year and "DDD" is the Julian day.

ENTER THE SITE ABBREVIATION

If <**S**> is chosen, enter the four-character site abbreviation. The site must exist in the "WALDCP.DAT" file. Figure 4-3 shows the WALLOPS4 site entry display.

EXAMINE THE DCP PARAMETERS

Verify that the DCP parameters displayed are correct for DCP data desired. Figure 4-4 shows the parameter verification display.

ENTER THE DATE AND TIME

Enter the date and time of the start of the interval desired. Figure 4-5 shows the date and time entry display. The download will proceed upon entering **Y** at the prompt. Figure 4-6 shows the display during the download process.

4.4 DCP TRANSMISSION QUALITY CHECK

The data satellite downlink facility analyzes DCP transmissions for transmission strength and quality. The data coordinator should check the downloaded data file for correct DCP operation as follows:

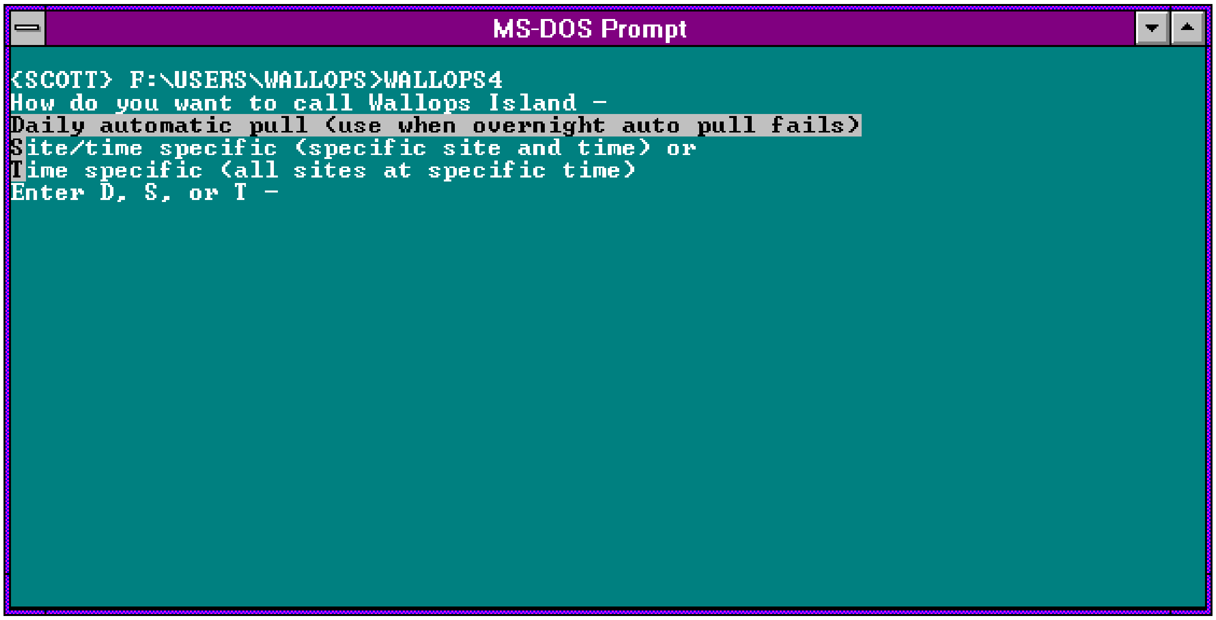

Figure 4-2. Starting WALLOPS4 Software.

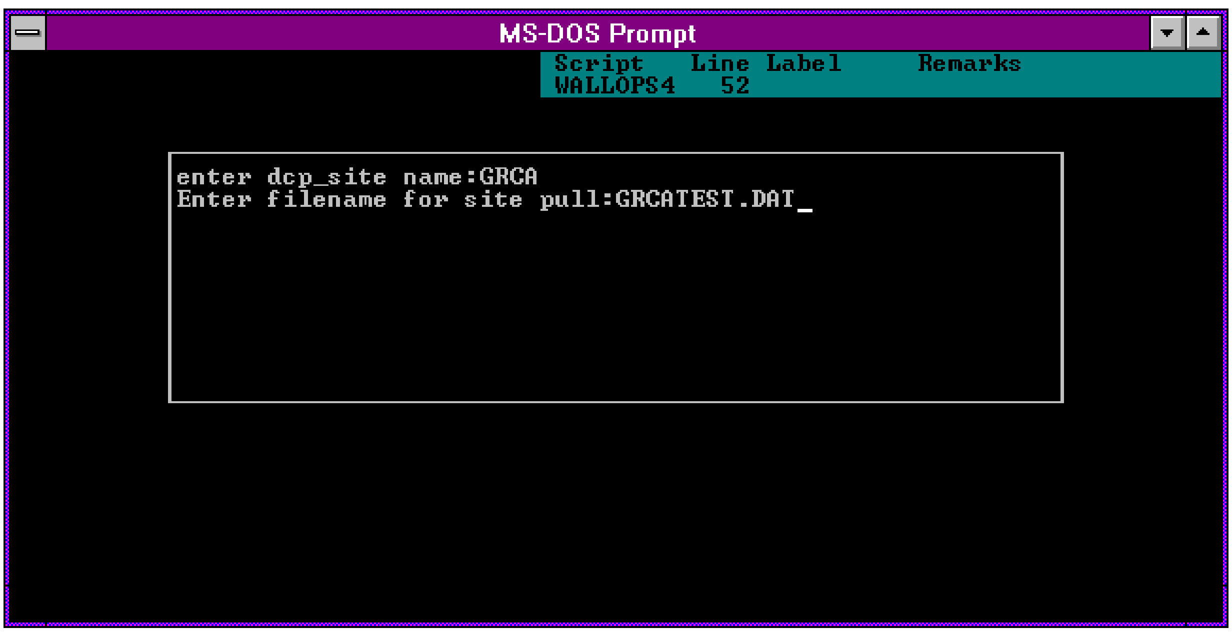

Figure 4-3. Entering Site Abbreviation and File Name in WALLOPS4 Software.

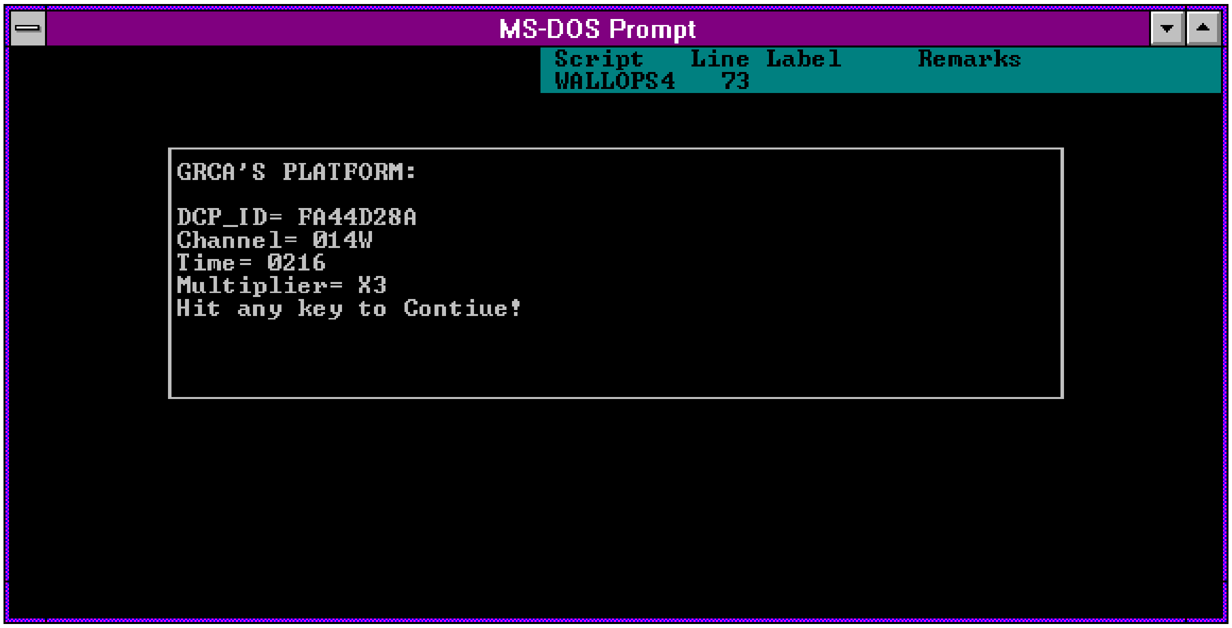

Figure 4-4. Verifying Download Parameters in WALLOPS4 Software.

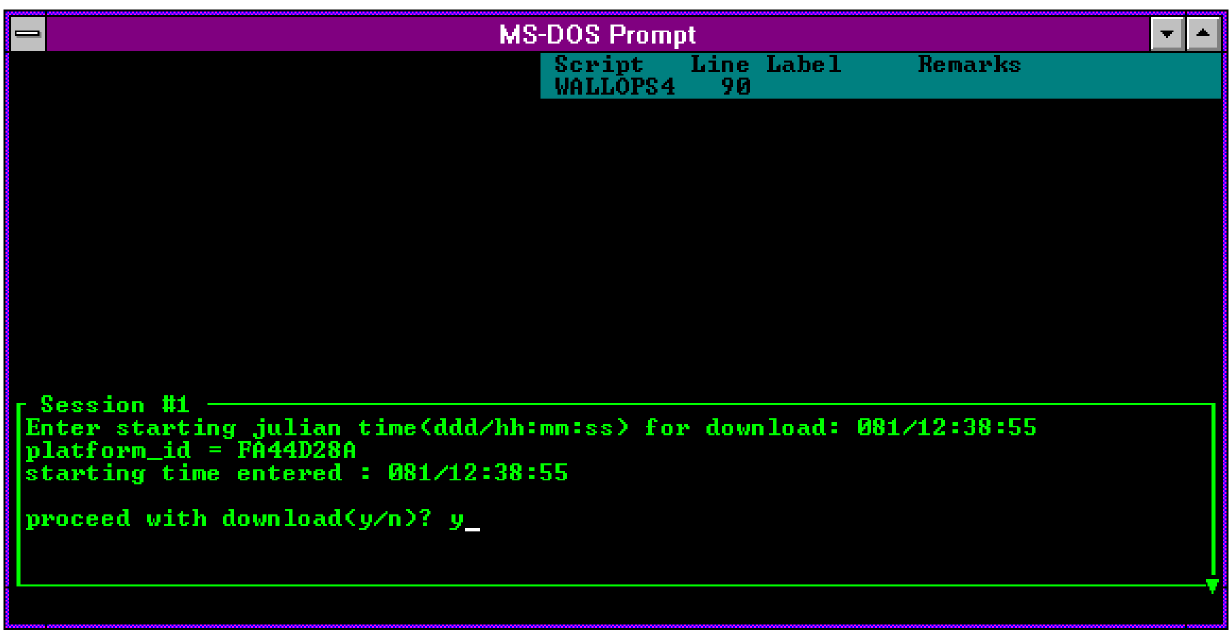

Figure 4-5. Starting the Download in WALLOPS4 Software.

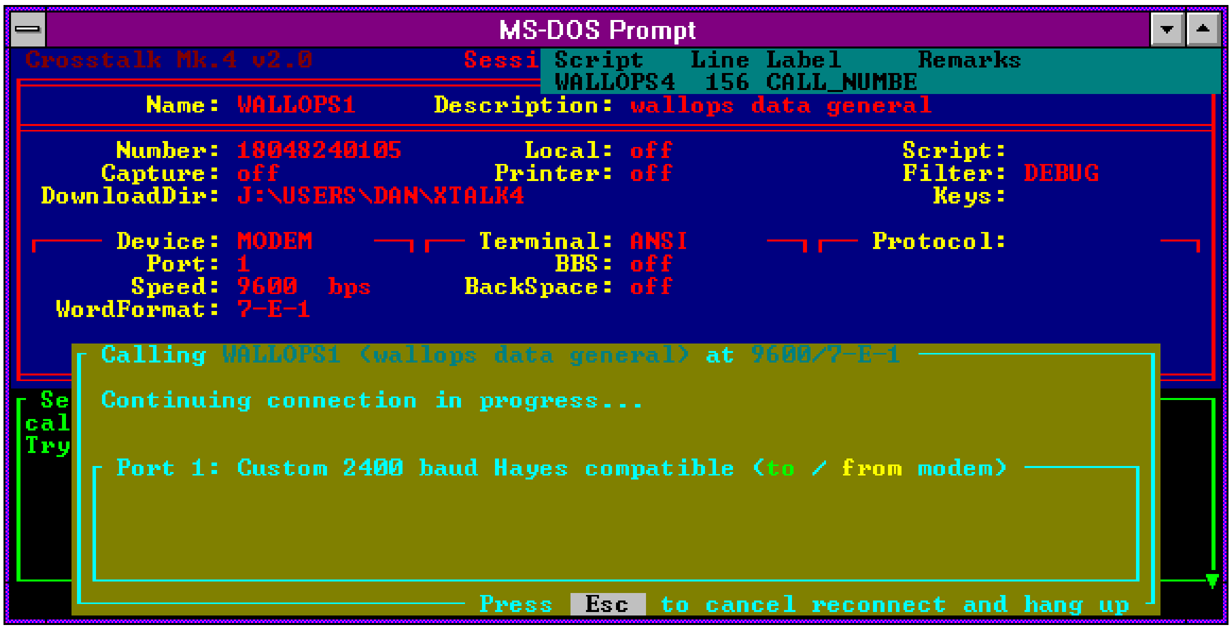

Figure 4-6. Downloading Data Display in WALLOPS4 Software.

- Edit the downloaded data file.
- Check the messages and news information at the beginning of the file.
- Check each DCP data transmission regarding:
  - DCP address.
  - Transmission time (year, Julian day, hour, minute, and second).
  - Failure code.
  - DAMS data quality measurements (signal strength, frequency deviation, modulation index, and modulation quality).
  - DCP transmission channel.
  - Message length.
  - Transmissometer, nephelometer, or meteorological data transmission format.

The following procedures detail the DCP transmission quality check:

EDIT THE DOWNLOADED FILE

Edit the downloaded file using any plain ASCII editor such as WordStar. The WordStar command is **WS FILENAME**. "FILENAME" is the downloaded data file, usually of the format "GALYYDDD.DAT," where "YY" is the year, and "DDD" is the Julian date.

CHECK MESSAGES AND NEWS

The downloaded data file may contain information about data dissemination processes, solar eclipses, data archiving, etc. This information may provide clues to failed DCP transmissions or poor quality data.

CHECK DCP TRANSMISSIONS

Each DCP transmission has associated quality assurance information added to the downloaded data file. Figure 4-7 details the information for a Handar DCP and Figure 4-8 details the information for a Synergetics DCP. Figure 4-9 details the ranges of acceptable values for the DCP transmission information. If any parameter is out of range, refer to TI 4110-3300, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*.

CHECK DATA FORMAT

Each type of monitoring station (transmissometer, nephelometer, or meteorological) logs different data and transmits a different data format. Figures 4-7 and 4-8 detail the data transmission formats for transmissometer and nephelometer stations, respectively. If the transmitted data are not in the correct format, refer to TI 4110-3000, *Troubleshooting and Emergency Maintenance Procedures for Optec LPV-2 Transmissometer Systems (IMPROVE Protocol)*, or TI 4100-3100, *Routine Site Operator Maintenance Procedures for NGN-2 Nephelometer Systems (IMPROVE Protocol)*.

Example Data	Row Description
`FA42914E93085112729G38+1HN009EFF00143`	Identification and quality
`0501 001 004 0137 090 000 000 000 00.0 13.8`	First hourly data
`0495 000 004 0138 088 000 000 000 00.0 13.8`	Second hourly data
`0496 001 003 0138 086 000 000 000 00.0 13.8`	Third hourly data
1 2 3 4 5 6 7 8 9 10	Data column

Column	Description
1	Raw transmission average (counts)
2	Receiver computer toggle
3	Standard deviation of the raw transmission (counts)
4	Ambient temperature (°F) (+ 100)
5	Ambient relative humidity (%)
6-9	Not used
10	DCP battery voltage (VDC)

Identification and transmission quality:

Characters	Example	Description
1-8	FA42914E	DCP identification
9-10	93	Year of transmission
11-13	085	Julian date of transmission
14-15	11	Hour of transmission
16-17	27	Minute of transmission
18-19	29	Second of transmission
20	G	Failure code
21-22	38	Signal strength
23-24	+1	Modulation frequency deviation from normal
25	H	Modulation quality
26	N	Modulation index
27-29	009	Satellite channel
30	E	Satellite (East or West)
31-32	FF	IFPD (Intermediate Frequency Presence Detector)
33-37	00143	Message length

Figure 4-7. Handar DCP Transmissometer Data Format.

Example Data									Description
FA40643E93085122318G43-1NN002W4C00432# 1	1716								Identification and quality
# 2	114	173	210	224	383	407	297	302	
# 2	383	140	135	140	125	132	138	128	
# 2	141	155							
# 3	498	498	498	498	498	498	498	498	
# 3	498	498	498	498	498	498	498	498	
# 3	498	498							
# 4	524	423	324						
# 5	50	50	50						
# 6	-1	-1	-1						
# 7	209	209	209						
# 8	1020	1020	1020						
# 9	96	92	102						
#10	960	954	926						
#11	1388								

Data Group Number	Description
#1	Synergetics operation status
#2	10-minute nephelometer analog A1 readings
#3	10-minute nephelometer analog A2 readings
#4	Nephelometer time when 21X datalogger time is xx:30
#5	Hourly nephelometer code summary
#6	Hourly support code summary
#7	Last clean air calibration (counts) (x10)
#8	Last span calibration (counts) (x10)
#9	Ambient temperature at top of hour (°C) (x10)
#10	Ambient relative humidity at top of hour (%) (x10)
#11	DCP battery voltage (VDC) (x100)

Identification and transmission quality:

Characters	Example	Description
1-8	FA40643E	DCP identification
9-10	93	Year of transmission
11-13	085	Julian date of transmission
14-15	12	Hour of transmission
16-17	23	Minute of transmission
18-19	18	Second of transmission
20	G	Failure code
21-22	43	Signal strength
23-24	-1	Modulation frequency deviation from normal
25	N	Modulation quality
26	N	Modulation index
27-29	002	Satellite channel
30	W	Satellite (East or West)
31-32	4C	IFPD (Intermediate Frequency Presence Detector)
33-37	00432	Message length

Figure 4-8. Synergetics DCP Nephelometer Data Format.

PARAMETER	RANGE	INTERPRETATION
SIGNAL STRENGTH	32 to 57	Signal strength should never exceed 50. Normal strength is 44 to 48. A signal strength less than 43 or greater than 49 indicates a possible malfunction or improper installation. Reliable data can be received with a signal strength as low as 37 if no other signal problems exist.
FREQUENCY	±0 to ±A	50 Hz increments. Reliable data should be possible between -8 and +8 (-449 to +449 Hz). Frequency drift due to temperature (+200 Hz) and Aging (+400 Hz/year) can cause a platform to drift outside the +500 HZ range very quickly. ±250 Hz is a safe range for normal operations.
MODULATION INDEX	N,H,L	N is normal. H (High); messages may be truncated or lost due to loss of demodulator lock. Signal strength readings may indicate too low. L (Low); high error rate, missing messages, and signal strength readings may read too high.
MODULATION QUALITY	N,F,P	N is normal. F indicates malfunction or misalignment, error rate between 10^{-4} and 10^{-6}. P indicates malfunction or misalignment, error rate worse than 10^{-4}.

Figure 4-9. DCP Transmission Quality Description.

4.5 DAILY DCP DATA HANDLING

Daily DCP data handling includes automatic removal of invalid characters from the downloaded file and reformatting the downloaded file into a form usable by processing software. Specifically, DCP data handling includes:

- Updating the "SITEINFO" file.
- Running the STRIP_T program to remove invalid characters and reformat the downloaded data file.
- Examining the stripped file to determine the beginning and ending dates and times for the interval of the file.
- Recording the interval in the Wallops Island log book.
- Examining the "ERROR.DAT" file for incomplete transmissions.
- Examining the "MESSAGE.DAT" file for information included in the header of the downloaded data file.

EDIT AND UPDATE THE "SITEINFO" FILE

The site list information file (SITEINFO) includes information for the current transmissometer and nephelometer sites, including associated DCP ID, site abbreviation, GMT time offset to Local Standard Time (LST), and number of lines in the DCP transmission. The information in the "SITEINFO" file is used by the STRIP_T and APPEND_T programs to define which DCP IDs are valid and to which site they are assigned. The "SITEINFO" file is located in the F:\USERS\WALLOPS directory. The "SITEINFO" file must be updated to reflect changes to DCP-related site configurations. The following procedures describe editing of the "SITEINFO" file:

- Edit the "SITEINFO" file using any plain ASCII editor such as WordStar. The WordStar command is **WS F:\USERS\WALLOPS\SITEINFO**.
- The file format for "SITEINFO" is detailed in Figure 4-10.
- Add, delete, or change the lines in the file to reflect the currently operating DCP-equipped stations.
- Update the number of stations in the first line of "SITEINFO" to reflect the number of stations listed in the file.
- Save the "SITEINFO" file. The WordStar command is **ALT F S**.

```
23
FA42914E,ACADH,4,3,ACADIA,OK,BEXT
FA4315A0,BADLH,7,3,BADLANDS,OK,BEXT
FA4380C2,BANDT,7,3,BANDELIER,OK,BEXT
FA4356AA,BIBEH,6,3,BIGBEND,OK,BEXT
FA43A62E,BRIDH,7,3,BRIDGER,OK,BEXT
FA44220E,BRMEO,7,6,BRYCECANYON,OK,NONE
FA44F466,CANYH,7,3,CANYONLANDS,OK,BEXT
FA450618,CHIRH,7,3,CHIRICAHUA,OK,BEXT
FA441794,GLACT,7,3,GLACIER,OK,BEXT
FA44E710,GRBAH,8,3,GREATBASIN,OK,BEXT
FA44D28A,GRCAH,7,3,GRANDCANYON(SOUTHRIM),OK,BEXT
FA43F652,GRCWH,7,3,GRANDCANYON(IN-CANYON),OK,BEXT
FA42F4A8,GRCMM,7,11,GRANDCANYONMET,OK,NONE
FA437046,GUMOH,6,3,GUADALUPE,OK,BEXT
FA4393B4,MEVEH,7,3,MESAVERDE,OK,BEXT
FA436330,PEFOH,7,3,PETRIFIEDFOREST,OK,BEXT
FA43203A,PINNH,8,3,PINNACLES,OK,BEXT
FA44C1FC,ROMOH,7,3,ROCKYMOUNTAIN,OK,BEXT
FA4306D6,SAGOH,8,3,SANGORGONIO,OK,BEXT
FA42C132,SHENH,4,3,SHENANDOAHLONGPATH,OK,BEXT
FA43B558,YELLH,6,3,YELLOWSTONE,OK,BEXT
FA42D244,YOSEH,8,3,YOSEMITE,OK,BEXT
FA40643E,MACAN,4,14,MAMMOTHCAVESNEPH,OK,NONE
```

Format:

The first line is the number of DCP definitions in the file.

All other lines:

DCP Identification
Site abbreviation and site type
Hourly offset to GMT
Number of lines in each transmission
Site name
Always OK if active; TEST if not active
Always b_{ext} if transmissometer; NONE if nephelometer

Site types:

T Transmissometer sites with Handar AT/RH sensor
H Transmissometer sites with Rotronics AT/RH sensor
N Nephelometer sites
O Bryce Canyon meteorological site

Figure 4-10. Example SITEINFO File for Daily Data Processing.

RUN STRIP_T

The STRIP_T program performs the following functions:

- Strips the downloaded data file of invalid characters.
- Saves the logon and file header information in the "MESSAGE.DAT" file.
- Saves incomplete transmissions in the "ERROR.DAT" file.
- Reformats the downloaded data file and sorts it by transmission date and time (GALYYDDD.TMP file).

  The downloaded data file must be run through STRIP_T before daily data processing of transmissometer or nephelometer data can proceed. The STRIP_T program is started by:

  - Changing to the F:\USERS\WALLOPS directory.
  - Entering **STRIP_T** to start the program.

RECORD START AND END TIMES

The stripped downloaded data file is sorted by transmission data and time. Examine the first and last transmissions in the "GALYYDDD.TMP" file and record them in the Wallops Island logbook.

EXAMINE ERROR FILE

The "ERROR.DAT" file in F:\USERS\WALLOPS contains incomplete transmissions from the downloaded data file. Examine this file for error messages. If error(s) exist, the data file contains incomplete transmissions that must be corrected.

The following procedures describe how to edit the "GALYYDDD.DAT" file that generated an error in the "ERROR.DAT" file:

- Edit the "GALYYDDD.DAT" file using any plain ASCII editor such as WordStar. The WordStar command is **WS F:\USERS\WALLOPS\GALYYDDD.DAT**.
- Each transmissometer data transmission format contains three lines of data following the header line as follows:

```
FA44D28A93110141630G51-1NN014WFF00143
0473 000 004 0136 026 000 000 000 00.0 12.8
0470 001 005 0135 026 000 000 000 00.0 12.8
0470 000 003 0139 023 000 000 000 00.0 13.1
```

- Add, delete, or change the lines in the data file so that the transmission format is complete. For example: the error is "FA44D28A93110011630, 2 lines does not = 3 lines," and the transmission in the "GALYYDDD.DAT" file looks like -

FA44D28A93110141630G51-1NN014WFF00143
0473 000 004 0136 026 000 000 000 00.0 12.8
0470 001 005 0135 026 000 000 000 00.0 12.8

Add a third line with 999's so the transmission looks like -

FA44D28A93110141630G51-1NN014WFF00143
0473 000 004 0136 026 000 000 000 00.0 12.8
0470 001 005 0135 026 000 000 000 00.0 12.8
9999 999 999 9999 999 999 999 999 9999 9999

Once errors are corrected, run STRIP_T again and reexamine the "ERROR.DAT" file. Do not proceed to the next processing stage until the "ERROR.DAT" file is free of errors. (See TI 4300-4023, *Transmissometer Daily Compilation and Review of DCP-Collected Data (IMPROVE Protocol)* or TI 4300-4004, *Nephelometer Data Compilation and Review of DCP-Collected Data (IMPROVE Protocol)*).

EXAMINE MESSAGE FILE

The "MESSAGE.DAT" file in F:\USERS\WALLOPS contains the header information from the downloaded data file. Print out a copy of "MESSAGE.DAT" daily and file the printout in the message archive file.

PERFORM DAILY DATA COMPILATION AND REVIEW

Once the primary data collection is complete, the next phase in daily data handling includes compilation and review of the collected data. Refer to the following data-specific TIs:

TI 4300-4004: *Nephelometer Data Compilation and Review of DCP-Collected Data (IMPROVE Protocol)*

TI 4300-4023: *Transmissometer Daily Compilation and Review of DCP-Collected Data (IMPROVE Protocol)*

4.6 UPDATING NESDIS PLATFORM DESCRIPTION TABLES (PDTs)

The NESDIS program information tables must be updated when any change in an operational parameter (location, etc.) occurs. Figure 4-11 details the contents of a typical PDT. Refer to the User Interface Manual (UIM) for the Data Collection System Automatic Processing System (DAPS), Version 1.1 for details on updating PDTs.

5.0 REFERENCES

Integral Systems, Inc., 1990, User Interface Manual (UIM) for the Data Collection System Automatic Processing System (DAPS), Version 1.1, September.

PARAMETER	DESCRIPTION
OWNER_ID	Owner user ID (must be in UDT)
PRIME_TYPE	Primary Type: S: Self-timed I: Interrogate R: Random D: Dual
PRIME_CHAN	Primary CHANNEL: 1 - 266 (must be in CDT)
PRIME_SCD	Primary GOES spacecraft assigned: E: East, W: West
SECND_ADDR	Secondary address or Null
SECND_TYPE	Secondary type: R: Random I: Interrogate, or Null Note: Valid PRIME/SECND types are S/I, S/R
SECND_CHAN	Secondary channel: 0 - 266 (must be in CDT if > 0)
SECND_SCID	Secondary GOES spacecraft assigned: E: East, W: West, or Null
TRIGGER_MODE	Trigger mode: S: Special, T: Test, or Null Note: if not Null then: (a) PRIME_TYPE must be R (b) SECND_ADDR (trigger id) required FIRST_XMT Time of first interrogation for I type platforms in HMMSS format
XMT_PERIOD	Time period between transmissions (S/D) Time period between interrogations (I) in HHMMSS format
XMT_WINDOW	Maximum transmission window size in MMSS (S/D)
XMT_RATE	Data transmission rate in bps (100/300/1200)
MAX_RETRIES	Maximum number of interrogation retries (I)
DATA_FORMAT	DCPRS data format: A: ASCII, B: Binary
PRIME_PREAMBLE	DCPRS preamble type: L: Long, S: Short
SECND_PREAMBLE	DCPRS preamble type: L: Long, S: Short, or Null
LOC_CODE	Three-character location code
LOC_REGION	Location category: A: United States, B: Canada, C: South America, O: Other
LOC_NAME	Location name (31 characters)
LATITUDE	Latitude in DDMMSS
LONGITUDE	Longitude in DDMMSS
MIN_ELEVATION	Minimum elevation angle of platform (in DD)
CATEGORY	Platform category: Fixed: Fixed-buoy, D: Drifting-buoy A: Aircraft, S: Ship B: Balloon, L: Land-based O: Other

Figure 4-11. DCP Platform Description Table (PDT) Description.

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**NEPHELOMETER DATA COLLECTION VIA TELEPHONE MODEM (IMPROVE PROTOCOL)**
TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4300-4002**
DATE	**MARCH 1993**

AUTHORIZATIONS

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REVISION HISTORY

REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	File format change	January 1995	
1.1	Minor text modifications.	June 1996	

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the steps of daily telephone modem collection, compilation, and review of nephelometer and meteorological data from an Optec NGN-2 ambient nephelometer station operated according to IMPROVE Protocol. The primary purpose of daily data collection via telephone modem is to assure quality data capture and minimize data loss by:

- Calling the Campbell 21X datalogger at each nephelometer/meteorological station via telephone modem and downloading the past day's data into site-specific daily files.
- Processing the raw data into Level-A validated form.
- Reviewing the daily nephelometer information file to verify nephelometer system operation or identify problems.

This TI, as referenced from Standard Operating Procedure (SOP) 4300, *Collection of Optical Monitoring Data (IMPROVE Protocol)*, is a guide for using the NGN_PULL nephelometer data processing software under Microsoft Windows to:

- Setup and update nephelometer station configurations.
- Perform automatic and manual data downloads.
- Perform automatic and manual daily data processing.
- Review daily nephelometer error files.

This TI assumes the operator has basic knowledge of IBM-PC compatible personal computers, the MS-DOS operating system, and Microsoft Windows 3.1.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall review daily error files and plots with the data coordinator to identify and correct problems.

2.2 DATA COORDINATOR

The data coordinator shall:

- Check the status of the automatic data collection daily to assure complete and error-free data collection.
- Verify correct operation of the automatic data processing.
- Review daily nephelometer information files with the project manager to identify and correct data collection problems.
- Enter any information relating to the collection of the data and operation of the nephelometer station into the site-specific Quality Assurance Database.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The nephelometer data collection system consists of the following hardware and software:

- IBM-PC compatible 386/486 computer system with VGA and 80 megabyte hard disk
- Internal or external Hayes compatible modem configured for COM port #2
- Microsoft Windows 3.0/3.1
- Campbell Scientific software:
  - TELCOM Version 1.0 or later
  - SMCOM Version 1.0 or later
  - TERM Version 1.0 or later
  - SPLIT Version 1.0 or later
- NGN_PULL software Version 3.0 or later (ARS software)

Information regarding Campbell Scientific software is detailed in the *Campbell Scientific PC208 DataLogger Support Software Instruction Manual*.

4.0 METHODS

This section includes three (3) major subsections:

4.1 Automatic Data Collection and Handling
4.2 Manual Data Collection and Handling
4.3 File Names and Contents

4.1 AUTOMATIC DATA COLLECTION AND HANDLING

Automatic data collection and processing is handled by NGN_PULL software which performs the following tasks:

- Polls each telephone modem station daily using the Campbell Scientific TELCOM program and retrieves data since the last download into site-specific daily files.
- Processes each site-specific daily file into instrument-specific parts:
  - 5-minute nephelometer, ambient temperature, and relative humidity
  - Hourly average wind speed, wind direction, temperature, and relative humidity
  - Hourly nephelometer status code and support system status code summaries
- Reformats, validates, and appends nephelometer data to seasonal site-specific Level-A data files.
- Reformats, validates, and appends meteorological data to seasonal site-specific files.
- Creates a daily nephelometer log file that contains a summary of the performance of all of the downloaded sites.

General automatic data collection and handling procedures include:

- Running the NGN_PULL software in Microsoft Windows 3.1.
- Updating the nephelometer station list to include all currently operating nephelometer stations to poll for data.
- Setting the time automatic data collection and processing is to begin.
- Starting the automatic data collection timer.
- Examining the daily nephelometer error files upon completion of daily downloading and processing, for information concerning the operation of the nephelometer stations.
- Examining and/or plotting the data in the Level-A files in accordance with TI 4400-5010, *Nephelometer Data Reduction and Validation (IMPROVE Protocol).*
- Performing manual data collection and processing, if automatic data collection or processing failed.

The following procedures detail the steps of nephelometer daily compilation and review:

LOGON TO NETWORK

Logon to the nephelometer data handling computer using your assigned user name and password.

RUNNING THE NGN-PULL PROGRAM

The NGN_PULL program runs in Microsoft Windows and coordinates both automatic and manual data downloading and processing functions. The program is run by double-clicking on the NGN-PULL icon in Windows, or selecting **FILE, RUN, NGN_PULL.EXE** from the program manager. Refer to the *Microsoft Windows 3.1 User's Guide* for details on running Windows programs. Figure 4-1 presents the screen display of the NGN_PULL program.

ADDING TO OR EDITING THE STATION LIST

The station list includes the nephelometer stations and station types that are currently operating. The list includes:

- Site abbreviation
- Site type (telephone modem or DCP)
- Days of the week to call
- ARS project code
- First and last date and time of last downloaded file
- Plot title
- DCP station ID and GMT time offset (if applicable)

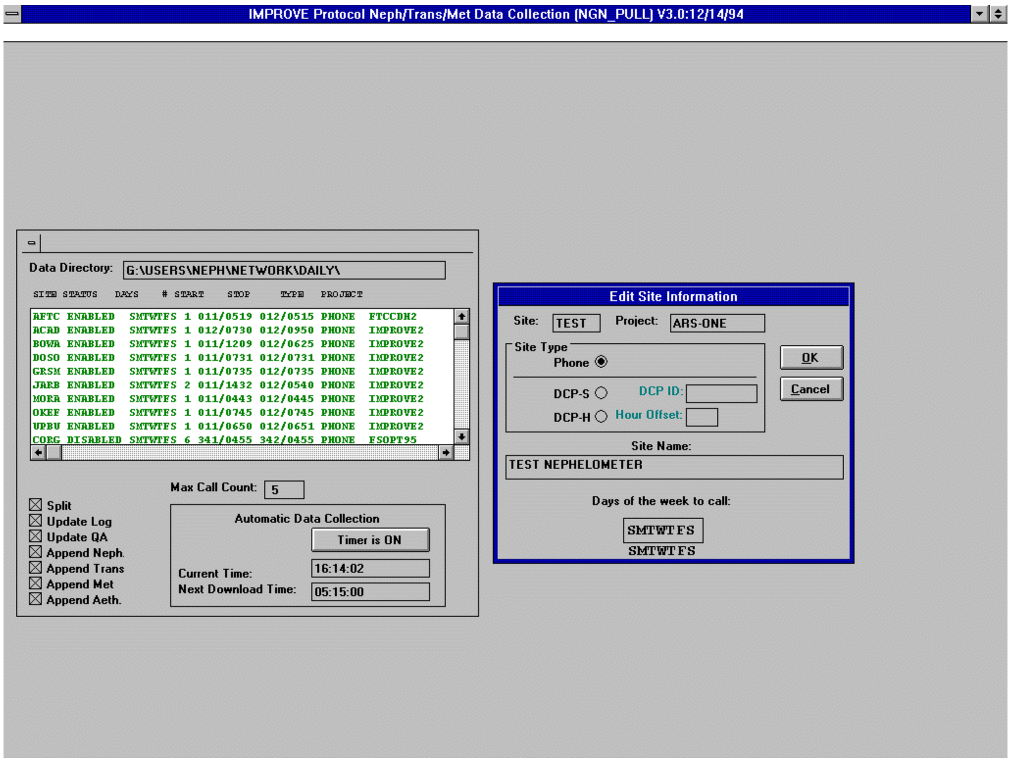

Figure 4-1. NGN_PULL Windows Program Screen.

The list may be edited by clicking **SITE** from the menu bar and then selecting **EDIT**, **ADD**, or **DELETE**. A site can be disabled (from calling) or enabled (to call) by clicking **SITE** from the menu bar and selecting **DISABLE** or **ENABLE**.

The telephone-type stations have a corresponding station definition file (XXXX.STN) that the TELCOM program uses for datalogger and modem-specific parameters (including the telephone number). The following procedures are used to add, edit, or remove a site from the station list:

To add a new site:

- Click **SITE** from the menu bar and select **ADD**.
- Complete the fields in the "Edit Site Information" dialog box.
- Click **OK**.

To edit an existing site:

- Highlight the site to edit in the site list box.
- Click **SITE** from the menu bar.
- Click **EDIT**.
- Complete the "Edit Site Information" dialog box.
- Click **OK**.
- Set the following parameters in the station definition file (see Figure 4-2):
    - Type of datalogger (21X)
    - Type of data file
    - Modem type, COM port, and baud rate
    - Telephone number

To remove a site:

- Highlight the site to remove in the site list box.
- Click **SITE** from the menu bar.
- Click **DELETE**.

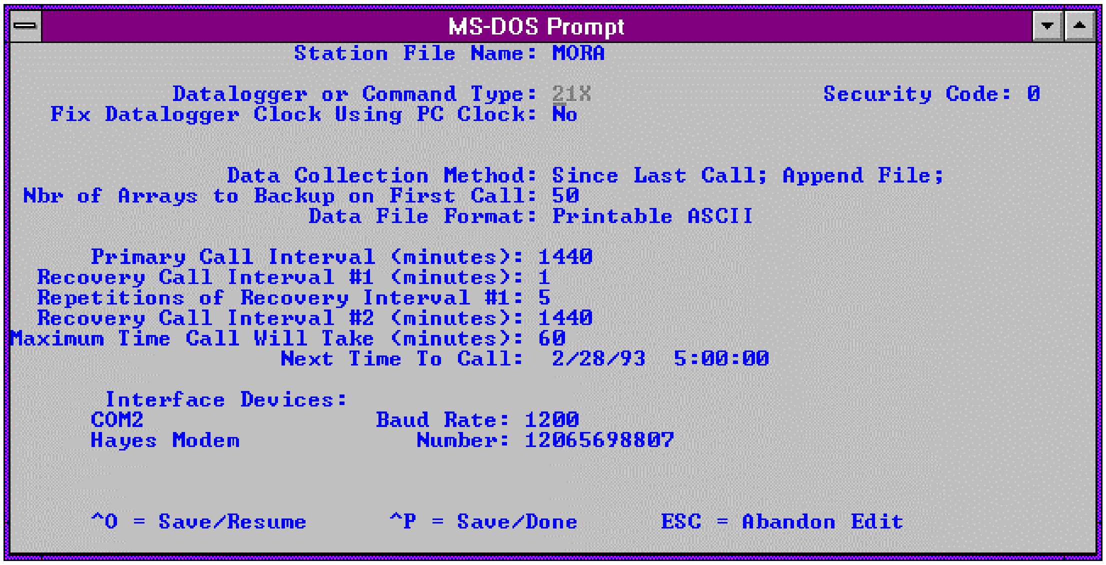

Figure 4-2. Editing a Station Definition File From NGN_PULL Using the TELCOM Program.

SETTING THE CALL (DATA DOWNLOAD) TIME

The call time is the time the first telephone modem station on the station list is called for data. The stations are called in the order of the station list. The call time may be changed as follows (see Figure 4-1):

- Click **OTHER** on the menu bar. Click **SET CALL/PROCESS TIME**.
- Enter the new call time in the dialog box that appears on the screen. The time format is HH:MM:SS (hour:minute:second).
- Click **OK** to save the time or **CANCEL** to ignore the change.

STARTING THE AUTOMATIC DATA COLLECTION TIMER

When the automatic data collection timer is running, the system time is compared to the call time and process time at 5-second intervals. When the times match, the call or process steps are started. When the timer is running, the system time is displayed on the screen. The timer may be started or stopped as follows (see Figure 4-1):

- Click the **TIMER IS ON** button to start the timer. The button will change to "TIMER IS OFF" and the current time will be displayed next to the button.

- Click the **TIMER IS OFF** button to stop the timer. The button will change to "TIMER IS ON" and the current time will disappear from the box next to the button.

EXAMINE THE DAILY NEPHELOMETER ERROR FILES

Daily nephelometer error files contain details about the success of the datalogger interrogation and operation of the nephelometer station. This information is contained in the downloaded data file and is extracted automatically during daily data processing. The following error files are created:

- NGNYYJJJ.ERR
  An error file created by TELECOM software when calling the site modem. The file contains the list of problems encountered while connecting with the on-site datalogger.

- NGNYYJJJ.INF
  A nephelometer system error file that includes non-ambient nephelometer occurrences (calibrations, rain, etc.) and problems with AC and DC power levels.

- NGNYYJJJ.PER
  A processing error file that includes processing problems of the raw data file.

Note: "YY" is the year and "JJJ" is the Julian date in these files.

The error files can be viewed as follows:

- Click **ERRORS** on the menu bar.

- Click one of the error files to view:

  - View **TELCOM** Errors

  - View **NEPHELOMETER** Errors

  - View **PROCESSING** Errors

- The error file will be loaded into Microsoft Notepad for viewing.

Figure 4-3 presents examples of the three types of error files. The data coordinator will review the daily error files and note problems requiring corrective actions. If required, the corrective actions highlighted in Table 4-1 will be implemented by the data coordinator as described in TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*.

Example Telcom Error File

```
TELCOM error at SHRO: 01/13/95 06:02:33 Smartmodem did not detect carrier!
TELCOM error at SHRO: 01/13/95 06:03:24 Smartmodem did not detect carrier!
TELCOM error at SHRO: 01/13/95 06:04:14 Smartmodem did not detect carrier!
TELCOM error at SHRO: 01/13/95 06:05:05 Smartmodem did not detect carrier!
TELCOM error at SHRO: 01/13/95 06:05:56 Smartmodem did not detect carrier!
TELCOM error at SHRO: 01/13/95 06:06:47 Smartmodem did not detect carrier!
TELCOM error at SEWZ: 01/13/95 06:30:20 Warning: 1 retries were logged.
TELCOM error at JUNZ: 01/13/95 06:39:22 Smartmodem did not detect carrier!
```

Example Nephelometer System Error File

```
=======================================================
==                  ACAD                             ==
=======================================================
SERIAL DATA: 1995  12  1447  3  49  2039  48  10  2.02  1  1433  49.42  2991  .748  95.6
SERIAL DATA: 1995  12  1448  5  152  .92  48  10  2.02  1  1433  49.42  4986  .817  95.5
RAIN EVENT       ( 1050 )  DATE: 1995  12 TIME: 1500
ZERO             ( 1150 )  DATE: 1995  12 TIME: 1600
BLUE EARTH RESET ( 2000 )  DATE: 1995  12 TIME: 2000

=======================================================
==                  BOWA                             ==
=======================================================
SERIAL DATA: 1995  12  700  2  129  3006  85  10 -2.31  1  647  87.3  1998 -4.222  92.2
ZERO             ( 150 )  DATE: 1995  12 TIME: 800
SERIAL DATA: 1995  12  1320  2  137  3023  90  10 -1.11  1  1307  92.1  1998 -2.71  93
ZERO             ( 150 )  DATE: 1995  12 TIME: 1400
SERIAL DATA: 1995  12  1940  2  161  3017  106  10 -2.11  1  1927  107.2  1998 -3.741  92.7
ZERO             ( 150 )  DATE: 1995  12 TIME: 2000
SERIAL DATA: 1995  13  25  5  217  .92  187  2 -4.48  1  20  187  4992 -5.73  91.2
```

Example Processing Error File

```
TRANSGETSITE: No lamp file! F:\USERS\SITE.CON\MACA_L
TRANSGETSITE: No lamp file! F:\USERS\SITE.CON\LOPE_L
TRANSGETSITE: No lamp file! F:\USERS\SITE.CON\SEWZ_L
VORZ: Suspect analog A2=-294.3)  JD= 12 TIME= 1605
VORZ: Suspect analog A2=-128.3)  JD= 12 TIME= 1610
TRANSGETSITE: No lamp file! F:\USERS\SITE.CON\VORZ_L
TRANSGETSITE: No lamp file! F:\USERS\SITE.CON\VORZ_L
```

Figure 4-3. Example Nephelometer Error Files Generated by NGN_PULL.

Table 4-1

Nephelometer Data Collection
Corrective Actions

Daily Nephelometer Information File			Corrective Action
Status Code	Site Abbrv.	Date/Time	
CHOPPER FAILURE	(xxxx)	DATE: 1993 063 TIME: 13:55	Reset nephelometer via phone modem or contact site operator.
RAIN EVENT	(xxxx)	DATE: 1993 063 TIME: 13:55	None required.
LAMP OUT	(xxxx)	DATE: 1993 063 TIME: 13:55	Have site operator change lamp.
SPAN	(xxxx)	DATE: 1993 063 TIME: 13:55	Enter span value in site-specific calibration file.
ZERO	(xxxx)	DATE: 1993 063 TIME: 13:55	None required.
BUFFER RESET	(xxxx)	DATE: 1993 063 TIME: 13:55	None required.
AC POWER OUT	(xxxx)	DATE: 1993 063 TIME: 13:55	Have site operator check support system AC fuse and main circuit breaker.
DC POWER LOW	(xxxx)	DATE: 1993 063 TIME: 13:55	Have site operator check support system DC fuse.
21X POWER LOW	(xxxx)	DATE: 1993 063 TIME: 13:55	None required.

4.2 MANUAL DATA COLLECTION AND HANDLING

Data may be collected from individual nephelometer stations. This manual method includes the following procedures:

- Running the NGN_PULL program in Windows software.
- Updating the nephelometer station list to include the currently operating nephelometer station to be polled (if necessary).
- Highlighting the station to be polled on the station list.
- Initiating the download.
- Processing the downloaded data file.
- Reviewing the daily nephelometer error files for information concerning the operation of the nephelometer stations.

Operation of the NGN_PULL program is described above in Section 4.1, Automatic Data Collection and Handling. Additional information related to manual data collection and handling and not covered above includes:

INITIATE MANUAL DOWNLOAD

The following procedures describe downloading data from a single station:

- Highlight the station to download on the station list.
- Click **DOWNLOAD** on the menu bar.
- Click **DOWNLOAD RECENT**, **DOWNLOAD ALL**, or **DOWNLOAD/PROCESS** to initiate manual data collection.
- Downloaded data will be placed in a file named "XXXXYYDN.JJJ", where "XXXX" is the site abbreviation, "YY" is the year, "N" is a character from A through 9, and "JJJ" is the julian date.
- If "DOWNLOAD/PROCESS" was clicked, the raw data file will process as during automatic operation.
- Review the error files as described in Section 4.1.

PROCESS MANUAL DOWNLOAD DATA

Downloaded data files may be processed similar to the automatic data collection sequence:

- Highlight the station to process in the station list.
- Click **PROCESS** on the menu bar.
- Click **PROCESS PHONE/SM**.

- A file selection dialog box will appear. Highlight the raw data file to process in the dialog box.
- Click **OK** on the menu bar.

4.3 FILE NAMES AND CONTENTS

4.3.1 Daily Data Compilation and Processing Files

Daily compilation and processing of nephelometer data involves several files. The following describes the processing steps and files used:

- Data for individual nephelometer stations are downloaded into site-specific data files (XXXXYYDN.JJJ, where "XXXX" is the site abbreviation, "YY" is the year, "N" is a character from A through 9, and "JJJ" is the Julian date). These files contain all data collected from the datalogger.
- Data in the site-specific files are divided into several instrument-specific temporary data files. Five-minute nephelometer and meteorological data are placed in "XXXX.NEP," hourly code summary information is placed in "XXXX.INF," and hourly meteorological data are placed in "XXXX.FSM."
- The 5-minute nephelometer and hourly meteorological data in the temporary files (XXXX.NEP) are appended to the following site-specific Level-A files:

  Nephelometer: XXXX_N.YYS

  Meteorological: XXXX_M.YYS

  (where "XXXX" is the site abbreviation, "YY" is the year, and "S" is the season code)
- Hourly code summary data are formatted and written to the daily nephelometer error file.
- Level-A files may be examined or plotted. These files serve as the initial files for further processing as detailed in TI 4400-5010, *Nephelometer Data Reduction and Validation (IMPROVE Protocol)*. The Level-A files are maintained on the system hard disk until completion of seasonal processing.
- Other files used by NGN_PULL include:

NGN_SITE.LST	A list of active sites that appear in the site list window of NGN_PULL
NGN_FILE.LST	A list of raw data file names already in use by NGN_PULL

4.3.2 Site-Specific Data File Description

The site-specific daily file consists of the following sets of data:

- Five-minute data synchronized to the 21X datalogger clock including nephelometer analog channels A1 and A2, ambient temperature, and relative humidity. The format is:

5-Minute Analog Data

01+0163. 02+1993. 03+0059. 04+0755. 05+582.6 06+0999. 07+2.234 08+097.1

Element #	Description
01	Datalogger program location identifier (not used)
02	Year
03	Julian date
04	Time (HHMM) at the end of the data period
05	Nephelometer A1 channel (mV x 2.0)
06	Nephelometer A2 channel (mV x 2.0)
07	Ambient air temperature (°C)
08	Ambient relative humidity (%)

- Five-minute data output when the nephelometer provides a serial data stream, including nephelometer serial data, analog channels A1 and A2, ambient temperature, and relative humidity. The format is:

5-Minute Serial

01+0119. 02+1993. 03+0059. 04+0757. 05+1.000 06+0891. 07+3493. 08+510.0
09+2.000 10+3.510 11+2.000 12+0755. 13+509.3 14+0999. 15+2.456 16+097.1

Element #	Description
01	Datalogger program location identifier (not used)
02	Year
03	Julian date
04	Time (HHMM) the serial stream was received by the datalogger
05	Nephelometer status code
06	Nephelometer raw scattered light reading (counts)
07	Nephelometer direct light reading (counts)
08	Nephelometer normalized scattered light reading (counts)
09	Nephelometer integration time (minutes)
10	Nephelometer chamber temperature (°C)
11	Not used
12	Nephelometer time (HHMM)
13	Nephelometer A1 channel (mV x 2.0)
14	Nephelometer A2 channel (mV x 2.0)
15	Ambient air temperature (°C)
16	Ambient relative humidity (%)

- Hourly code summary for the nephelometer and support system. The format is:

Hourly Code Summary

01+0104. 02+1993. 03+0059. 04+0800. 05+50.00 06+0.000

Element #	Description
01	Datalogger program location identifier (not used)
02	Year
03	Julian date
04	Time (HHMM) at the end of the data period
05	Nephelometer code summary for the past hour
06	Support system code summary for the past hour

The nephelometer code summary is the sum of any or all of the following:

50	Ambient reading
100	Clean air calibration
300	Span calibration
500	Lamp burned out
1000	Precipitation event detected
2000	Chopper motor start-up failure

The support system code summary is the sum of any or all of the following:

300	21X datalogger power low
500	DC power supply voltage low
1000	AC power outage
2000	Blue Earth serial data buffer restarted

- Hourly average meteorological data including wind speed, wind direction, ambient temperature, and relative humidity. The format is:

Hourly Meteorological Data

01+0171. 02+1995. 03+0013. 04+0700. 05-3.765 06+090.2 07+6.975 08+312.9 09+13.67

Element #	Description
01	Datalogger program location identifier (not used)
02	Year
03	Julian date
04	Time (HHMM) at the end of the data period
05	Ambient temperature (°F)
06	Relative humidity (%)
07	Wind speed (mph)
08	Wind direction (degrees true)

4.3.3 Level-A Nephelometer File Description

The level-A nephelometer file is a formatted ASCII site-specific file. A key to the Level-A file format is presented in Figure 4-4.

Field

```
  1     2     3   4    5    6       7       8      9      10      11     12     13      14
< 10 line informational header at start of file >
VORZ 941228 362 0110  10  212.17  212.60 -99.00 -99.00 -99.000  -5.68  -5.44  83.10   3912
VORZ 941228 362 0115  10  209.77  207.90 -99.00 -99.00 -99.000  -5.74  -5.37  83.20   3909
VORZ 941228 362 0120  10  210.58  209.90 -99.00 -99.00 -99.000  -5.74  -5.51  83.30   3913
```

Field #	Description
1	Site abbreviation
2	Year, month , day (YYMMDD)
3	Julian date (JJJ)
4	Time (HHMM)
5	Code summary (3-characters)
	1: Power code (non-space character = power problem)
	2: Nephelometer status code
	1 = ambient
	2 = zero
	3 = span
	4 = lamp
	5 = rain
	6 = chopper
	3: Nephelometer data type code
	0 = serial
	1 = analog
	2 = DCP
6	Nephelometer serial or analog normalized reading (counts)
7	Nephelometer serial normalized reading calculated from the raw readings (counts)
8-10	Not used
11	Chamber temperature (°C)
12	Ambient air temperature (°C)
13	Ambient relative humidity (%)
14	Raw lamp brightness (counts)

Figure 4-4. Key to the Level-A Nephelometer File Format.

4.3.4 Level-A Meteorological File Description

The level-A meteorological file is a formatted ASCII site-specific file. A key to the Level-A file format is presented in Figure 4-5.

5.0 REFERENCES

Campbell Scientific, Inc., Feb. 1989, Campbell Scientific PC208 Datalogger Support Software Instruction Manual.

Microsoft Corporation, 1992, Microsoft Windows 3.1 User's Guide.

Field

1	2	3	4	5	6	7	8	9
CORG	941201	335	0000	50.30	69.12	17.36	273.00	12.27
CORG	941201	335	0100	49.27	73.80	14.20	268.80	34.81
CORG	941201	335	0200	49.51	74.30	14.98	275.60	8.25

Field #	Description
1	Site abbreviation
2	Year, month , day (YYMMDD)
3	Julian date (JJJ)
4	Time (HHMM), hour ending
5	Hourly average ambient air temperature (°F)
6	Hourly average ambient relative humidity (%)
7	Hourly average wind speed (mph)
8	Hourly average wind direction (degrees true)
9	Hourly standard deviation wind direction (degrees)

Figure 4-5. Key to the Level-A Meteorological File Format.

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**NEPHELOMETER DATA COMPILATION AND REVIEW OF DCP-COLLECTED DATA (IMPROVE PROTOCOL)**
TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4300-4004**
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AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
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OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	File format change	March 1995	
1.1	Minor text modifications	June 1996	

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the steps of daily compilation and review of DCP nephelometer and meteorological data from an Optec NGN-2 ambient nephelometer station operated according to IMPROVE Protocol. The primary purpose of daily data compilation and review is to assure quality data capture and minimize data loss by:

- Extracting each site's DCP nephelometer and meteorological data from the daily data file downloaded from the NOAA/NESS data dissemination facility at Wallops Island, Virginia. This file is obtained according to Standard Operating Procedure (SOP) 4300, *Collection of Optical Monitoring Data (IMPROVE Protocol)* and TI 4300-4000, *Data Collection via DCP (IMPROVE Protocol)*.

- Reformatting downloaded DCP data to provide a format compatible with NGN_PULL nephelometer data processing software.

- Processing raw data into Level-A validated form using NGN_PULL software.

- Reviewing the daily nephelometer information file to verify nephelometer system operation or identify problems.

This TI is a guide for using the NGN_PULL nephelometer data processing software under Microsoft Windows to:

- Setup and update the nephelometer station configurations.

- Reformat the daily stripped downloaded DCP data file.

- Perform automatic and manual daily data processing.

- Review the daily nephelometer log file.

This TI assumes the operator has basic knowledge of IBM-PC compatible personal computers, the MS-DOS operating system, and Microsoft Windows 3.1.

This TI also assumes that data from operational nephelometer stations have been downloaded from Wallops Island in accordance with TI 4300-4000.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall review daily nephelometer log files and plots with the data coordinator to identify and correct problems.

2.2 DATA COORDINATOR

The data coordinator shall:

- Perform daily processing of DCP data.

- Verify correct operation of the data processing software.
- Review the daily nephelometer log file with the project manager to identify and correct nephelometer station operation problems.
- Enter any information relating to the collection of the data and operation of the nephelometer station into the site-specific Quality Assurance Database.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The nephelometer data collection system consists of the following hardware and software:

- IBM-PC compatible 386/486 computer system with VGA and 80 megabyte hard disk
- Internal or external Hayes compatible modem configured for COM port #2
- Microsoft Windows 3.0/3.1
- NGN_PULL software Version 3.0 or later (ARS software)

4.0 METHODS

This section includes two (2) major subsections:

4.1 Data Collection and Processing
4.2 File Names and Contents

4.1 DATA COLLECTION AND PROCESSING

Collection of DCP data is performed in accordance with TI 4300-4000, *Data Collection via DCP (IMPROVE Protocol)*. DCP data processing is handled by NGN_PULL software which performs the following tasks:

- Extracts nephelometer data from the stripped downloaded DCP file into site-specific daily data files formatted to be compatible with data obtained via telephone modem.
- Processes each site-specific daily file into instrument-specific parts:
  - 10-minute nephelometer, ambient temperature, and relative humidity
  - Hourly nephelometer status code and support system status code summaries
- Reformats, validates, and appends nephelometer data to seasonal site-specific Level-A data files.
- Creates a daily nephelometer log file that contains a summary of the performance of all of the sites.

The following procedures detail the steps of nephelometer data compilation and review:

LOGON TO NETWORK

Logon to the nephelometer data handling computer using your assigned user name and password.

RUNNING THE NGN-PULL PROGRAM

The NGN_PULL program runs in Microsoft Windows and coordinates both automatic and manual data downloading and processing functions. The program is run by double-clicking on the NGN_PULL icon in Windows, or selecting **FILE, RUN, NGN_PULL.EXE** from the program manager. Refer to the *Microsoft Windows 3.1 User's Guide* for details on running Windows programs. Figure 4-1 presents the screen display of the NGN_PULL program.

ADDING TO OR EDITING THE STATION LIST

The station list includes the nephelometer stations and station types that are currently operating. The list includes the following:

- Site abbreviation
- Site type (telephone modem or DCP)
- Days of the week to call
- ARS project code
- First and last date and time of last downloaded file
- Plot title
- DCP station ID and GMT time offset (if applicable)

The list may be edited by clicking **SITE** from the menu bar and then selecting **EDIT**, **ADD**, or **DELETE**. A site can be disabled (from calling) or enabled (to call) by clicking **SITE** from the menu bar and selecting **DISABLE** or **ENABLE**.

<u>To add a new site</u>:

- Click **SITE** from the menu bar and select **ADD**.
- Complete the fields in the "Edit Site Information" dialog box.
- Click **OK**.

<u>To edit an existing site</u>:

- Highlight the site to edit in the site list box.
- Click **SITE** from the menu bar.
- Click **EDIT**.
- Complete the "Edit Site Information" dialog box.
- Click **OK**.

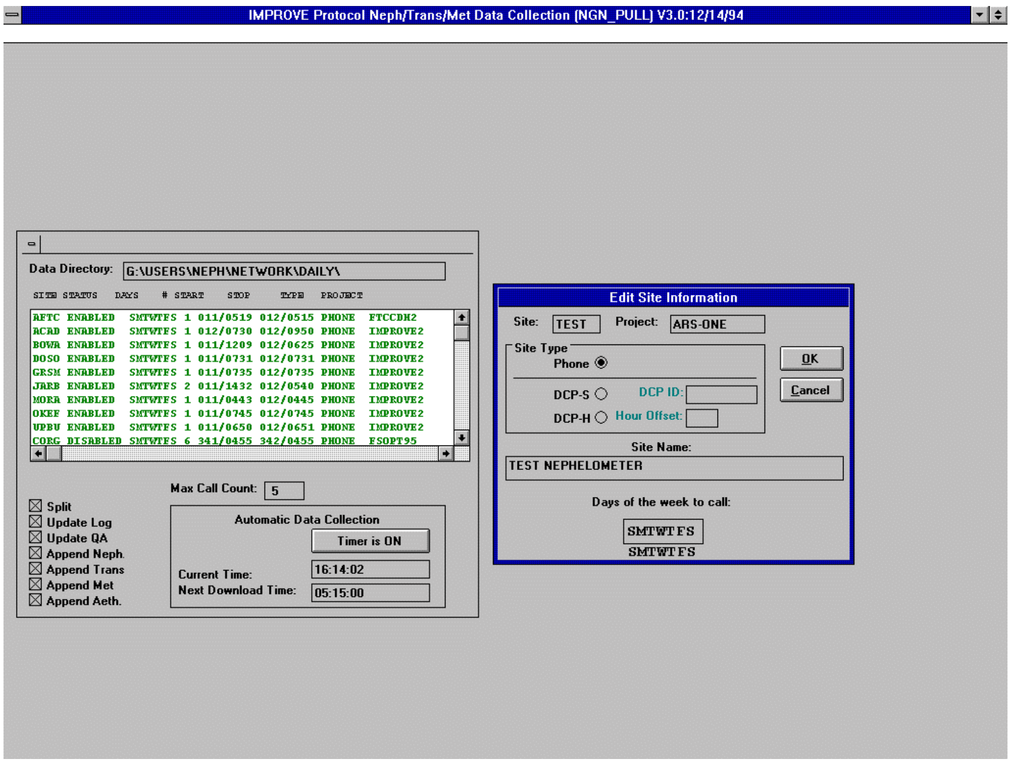

Figure 4-1. NGN_PULL Windows Program Screen.

To remove a site:

- Highlight the site to remove in the site list box.
- Click **SITE** from the menu bar.
- Click **DELETE**.

PROCESS MANUAL DOWNLOAD DATA

A downloaded data file is processed as follows:

- Highlight the station to process in the station list.
- Click **PROCESS** on the menu bar.
- Click **PROCESS DCP**.
- A file selection dialog box will appear. Highlight the stripped data file to process in the dialog box.
- Click **OK** on the menu bar.

EXAMINE THE DAILY NEPHELOMETER ERROR FILES

Daily nephelometer error files contain details about the success of the datalogger interrogation and operation of the nephelometer station. This information is contained in the downloaded data file and is extracted automatically during daily data processing. The following error files are created:

- NGNYYJJJ.INF
  A nephelometer system error file that includes non-ambient nephelometer occurrences (calibrations, rain, etc.) and problems with AC and DC power levels.
- NGNYYJJJ.PER
  A processing error file that includes processing problems of the raw data file.

  Note: "YY" is the year and "JJJ" is the Julian date in these files.

The error files can be viewed as follows:

- Click **ERRORS** on the menu bar.
- Click one of the error files to view:
  - View **NEPHELOMETER** Errors
  - View **PROCESSING** Errors
- The error file will be loaded into Microsoft Notepad for viewing.

Figure 4-2 presents examples of the two types of error files. The data coordinator will review the daily error files and note problems requiring corrective actions. If required, the corrective actions highlighted in Table 4-1 will be implemented by the data coordinator as described in TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*.

4.2 FILE NAMES AND CONTENTS

4.2.1 Daily Data Compilation and Processing Files

Daily compilation and processing of nephelometer data involves several files. The following describes the processing steps and files used:

- Data for all DCP sites are included in one daily file downloaded via telephone from the Wallops Island ground station. The file name is of the form "GALYYJJJ.DAT," where "YY" is the year and "JJJ" is the Julian date. Raw data are stripped of invalid characters and reformatted. The name of the stripped data file is of the form "GALYYJJJ.TMP." DCP data includes only a small subset of all data collected by the on-site Campbell 21X datalogger.

- Data in the stripped file are divided into several instrument-specific temporary data files. Ten-minute nephelometer and meteorological data are placed in "XXXX.NEP," and hourly code summary information is placed in "XXXX.INF."

- The 10-minute nephelometer and hourly meteorological data in the temporary files (XXXX.NEP) are appended to the following site-specific Level-A files:

  Nephelometer: XXXX_N.YYS

  Meteorological: XXXX_M.YYS

  (where "XXXX" is the site abbreviation, "YY" is the year, and "S" is the season code)

- Hourly code summary data are formatted and written to the daily nephelometer error file.

- Level-A files may be examined or plotted. These files serve as the initial files for further processing as detailed in TI 4400-5010, *Nephelometer Data Reduction and Validation (IMPROVE Protocol)*. The Level-A files are maintained on the system hard disk until completion of seasonal processing.

- Other files used by NGN_PULL include:

  NGN_SITE.LST — A list of active sites that appear in the site list window of NGN_PULL

  NGN_FILE.LST — A list of raw data file names already in use by NGN_PULL

Example Nephelometer System Error File

```
=======================================================
==                  ACAD                             ==
=======================================================
SERIAL DATA: 1995  12  1447  3  49  2039  48  10  2.02  1  1433  49.42  2991  .748  95.6
SERIAL DATA: 1995  12  1448  5  152  .92  48  10  2.02  1  1433  49.42  4986  .817  95.5
RAIN EVENT       ( 1050 )  DATE: 1995  12 TIME: 1500
ZERO             ( 1150 )  DATE: 1995  12 TIME: 1600
BLUE EARTH RESET ( 2000 )  DATE: 1995  12 TIME: 2000

=======================================================
==                  BOWA                             ==
=======================================================
SERIAL DATA: 1995  12  700  2  129  3006  85  10 -2.31  1  647  87.3  1998 -4.222  92.2
ZERO             ( 150 )  DATE: 1995  12 TIME: 800
SERIAL DATA: 1995  12  1320  2  137  3023  90  10 -1.11  1  1307  92.1  1998 -2.71  93
ZERO             ( 150 )  DATE: 1995  12 TIME: 1400
SERIAL DATA: 1995  12  1940  2  161  3017  106  10 -2.11  1  1927  107.2  1998 -3.741  92.7
ZERO             ( 150 )  DATE: 1995  12 TIME: 2000
SERIAL DATA: 1995  13  25  5  217  .92  187  2 -4.48  1  20  187  4992 -5.73  91.2
```

Example Processing Error File

```
TRANSGETSITE: No lamp file! F:\USERS\SITE.CON\MACA_L
TRANSGETSITE: No lamp file! F:\USERS\SITE.CON\LOPE_L
TRANSGETSITE: No lamp file! F:\USERS\SITE.CON\SEWZ_L
VORZ: Suspect analog A2=-294.3)  JD= 12 TIME= 1605
VORZ: Suspect analog A2=-128.3)  JD= 12 TIME= 1610
TRANSGETSITE: No lamp file! F:\USERS\SITE.CON\VORZ_L
TRANSGETSITE: No lamp file! F:\USERS\SITE.CON\VORZ_L
```

Figure 4-2. Example Nephelometer Error Files Generated by NGN_PULL.

Table 4-1

Nephelometer Data Collection
Corrective Actions

Daily Nephelometer Information File			Corrective Action
Status Code	Site Abbrv.	Date/Time	
CHOPPER FAILURE	(xxxx)	DATE: 1993 063 TIME: 13:55	Reset nephelometer via phone modem or contact site operator.
RAIN EVENT	(xxxx)	DATE: 1993 063 TIME: 13:55	None required.
LAMP OUT	(xxxx)	DATE: 1993 063 TIME: 13:55	Have site operator change lamp.
SPAN	(xxxx)	DATE: 1993 063 TIME: 13:55	Enter span value in site-specific calibration file.
ZERO	(xxxx)	DATE: 1993 063 TIME: 13:55	None required.
BUFFER RESET	(xxxx)	DATE: 1993 063 TIME: 13:55	None required.
AC POWER OUT	(xxxx)	DATE: 1993 063 TIME: 13:55	Have site operator check support system AC fuse and main circuit breaker.
DC POWER LOW	(xxxx)	DATE: 1993 063 TIME: 13:55	Have site operator check support system DC fuse.
21X POWER LOW	(xxxx)	DATE: 1993 063 TIME: 13:55	None required.

4.2.2 Daily Stripped Downloaded DCP File

The daily stripped downloaded data file consists of the following:

- 10-minute data synchronized to the DCP clock including nephelometer analog channels A1 and A2.
- Hourly data including nephelometer and support system code summaries, last clean air and span calibrations, and single point air temperature and relative humidity.

A key to the daily stripped data file format is presented in Figure 4-3.

4.2.3 Level-A Nephelometer File Description

The level-A file is a formatted ASCII site-specific file. A key to the Level-A data file format is presented in Figure 4-4.

5.0 REFERENCES

Microsoft Corporation, 1992, Microsoft Windows 3.1 User's Guide.

Line #	Data							
1	FA4051A4 93 052 21:22:15							
2	32	32	32	32	33	33	33	33
3	33	32	32	41	41	2	2	32
4	32	32						
5	999	999	999	999	999	999	999	999
6	999	1995	2990	999	999	0	0	999
7	999	1995						
8	1526	1410	1125					
9	50	150	150					
10	0	0	500					
11	290	290	290					
12	801	801	801					
13	212	213	209					
14	195	179	194					
15	1364							

Line #	Description
1	Wallops ID, year, Julian date, time (HH:MM:SS) of the DCP transmission
2-4	Last 18 nephelometer analog channel A1 readings (mV)
5-7	Last 18 nephelometer analog channel A2 readings (mV)
8	Last 3 hourly nephelometer time when 21X datalogger time is XX:30
9	Last 3 hourly nephelometer code summaries
10	Last 3 hourly support system code summaries
11	Last 3 hourly clean air calibrations (counts)
12	Last 3 hourly span calibrations (counts)
13	Last 3 hourly single-reading ambient air temperature readings (°C x 10.0)
14	Last 3 hourly single-reading relative humidity readings (% x 10.0)
15	DCP battery voltage (VDC x 100.0)

Figure 4-3. Key to the Daily Stripped Data File Format.

Field

```
  1      2     3   4    5    6       7       8      9      10      11     12     13      14
< 10 line informational header at start of file >
VORZ 941228 362 0110  10  212.17  212.60 -99.00 -99.00 -99.000  -5.68  -5.44  83.10   3912
VORZ 941228 362 0115  10  209.77  207.90 -99.00 -99.00 -99.000  -5.74  -5.37  83.20   3909
VORZ 941228 362 0120  10  210.58  209.90 -99.00 -99.00 -99.000  -5.74  -5.51  83.30   3913
```

Field #	Description
1	Site abbreviation
2	Year, month , day (YYMMDD)
3	Julian date (JJJ)
4	Time (HHMM)
5	Code summary (3-characters) 1: Power code (non-space character = power problem) 2: Nephelometer status code 1 = ambient 2 = zero 3 = span 4 = lamp 5 = rain 6 = chopper 3: Nephelometer data type code 0 = serial 1 = analog 2 = DCP
6	Nephelometer serial or analog normalized reading (counts)
7	Nephelometer serial normalized reading calculated from the raw readings (counts)
8-10	Not used
11	Chamber temperature (°C)
12	Ambient air temperature (°C)
13	Ambient relative humidity (%)
14	Raw lamp brightness (counts)

Figure 4-4. Key to the Level-A Data File Format.

Air Resource
Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**NEPHELOMETER DATA COLLECTION VIA CAMPBELL SCIENTIFIC DATA STORAGE MODULE (IMPROVE PROTOCOL)**
TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4300-4006**
DATE	**MARCH 1993**

AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
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OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	File format change	January 1995	
1.1	Minor text modifications.	June 1996	

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the collection, compilation, and review of Optec NGN-2 nephelometer and associated meteorological data stored on Campbell Scientific data storage modules. It specifically addresses data from nephelometer stations operated according to IMPROVE Protocol. The primary purpose of data collection via storage module is to assure quality data capture and minimize data loss by:

- Downloading data from the storage module into site-specific daily files.
- Processing raw data into Level-A validated form.
- Reviewing the nephelometer information file to verify nephelometer system operation or to identify problems.

This TI, as referenced from Standard Operating Procedure (SOP) 4300, *Collection of Optical Monitoring Data (IMPROVE Protocol)*, is a guide for using the NGN_PULL nephelometer data processing software under Microsoft Windows to:

- Setup and update the nephelometer station configurations.
- Download data from Campbell Scientific storage modules.
- Perform manual data processing.
- Review the nephelometer information file.

This TI assumes the operator has basic knowledge of IBM-PC compatible personal computers, the MS-DOS operating system, and Microsoft Windows 3.0/3.1.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall review information files and plots with the data coordinator to identify and correct problems.

2.2 DATA COORDINATOR

The data coordinator shall:

- Download the storage module and process the raw data.
- Review the nephelometer information files with the project manager to identify and correct data collection problems.
- Enter any information relating to the collection of the data and operation of the nephelometer station into the site-specific Quality Assurance Database.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The nephelometer data collection system consists of the following hardware and software:

- IBM-PC compatible 386/486 computer system with VGA and 80 megabyte hard disk
- Internal or external Hayes compatible modem configured for COM port #2
- Microsoft Windows 3.0/3.1
- Campbell Scientific software:
    - TELCOM Version 4.0 or later
    - SMCOM Version 4.0 or later
    - TERM Version 4.0 or later
- NGN_PULL software Version 3.0 or later (ARS)
- Campbell Scientific SC532 storage module interface

Information on the Campbell Scientific software is detailed in the *Campbell Scientific PC208 Datalogger Support Software Instruction Manual*.

4.0 METHODS

This section includes two (2) major subsections:

4.1 Storage Module Data Collection and Handling
4.2 File Names and Contents

4.1 STORAGE MODULE DATA COLLECTION AND HANDLING

Storage module data collection and handling is executed by the NGN_PULL program which performs the following tasks:

- Downloads data from the storage module using the Campbell Scientific SMCOM software into site-specific files.
- Processes each site-specific daily file into instrument-specific parts:
    - 5-minute nephelometer, ambient temperature, and relative humidity
    - Hourly average wind speed, wind direction, temperature, and relative humidity
    - Hourly nephelometer status code and support system status code summaries
    - Hourly average transmissometer, temperature, and relative humidity
- Reformats, validates, and appends each site's nephelometer data to seasonal site-specific Level-A data files.

- Creates a daily nephelometer log file that contains a summary of the performance of all the downloaded sites.

Collection and handling procedures of data on storage modules include:

- Running the NGN_PULL program in Microsoft Windows 3.0/3.1.
- Updating the nephelometer station list to include all currently operating nephelometer stations to poll for data.
- Verifying that the SC532 interface is installed to COM1 and powered.
- Verifying that the storage module is attached to the SC532 interface.
- Downloading the data from the storage module.
- Processing the site-specific data file manually.
- Examining the daily information file for information concerning the operation of the nephelometer stations upon completion of the download and process steps.
- Examining or plotting the data in Level-A files in accordance with TI 4400-5010, *Nephelometer Data Reduction and Validation (IMPROVE Protocol)*.

The following procedures detail the steps for data collection from a storage module:

LOGON TO NETWORK

Logon to the nephelometer data handling computer using your assigned user name and password.

RUNNING THE NGN_PULL PROGRAM

The NGN_PULL program runs in Microsoft Windows and coordinates both automatic and manual data downloading and processing functions. The program is run by double-clicking on the NGN_PULL icon in Windows, or selecting **FILE, RUN, NGN_PULL.EXE** from the program manager. Refer to the *Microsoft Windows 3.1 User's Guide* for details on running Windows programs. Figure 4-1 presents the screen display of the NGN_PULL program.

ADDING TO OR EDITING THE STATION LIST

The station list includes the nephelometer stations and station types that are currently operating. The list includes the following:

- Site abbreviation
- Site type (telephone modem or DCP)
- Days of the week to call
- ARS project code
- First and last date and time of last downloaded file

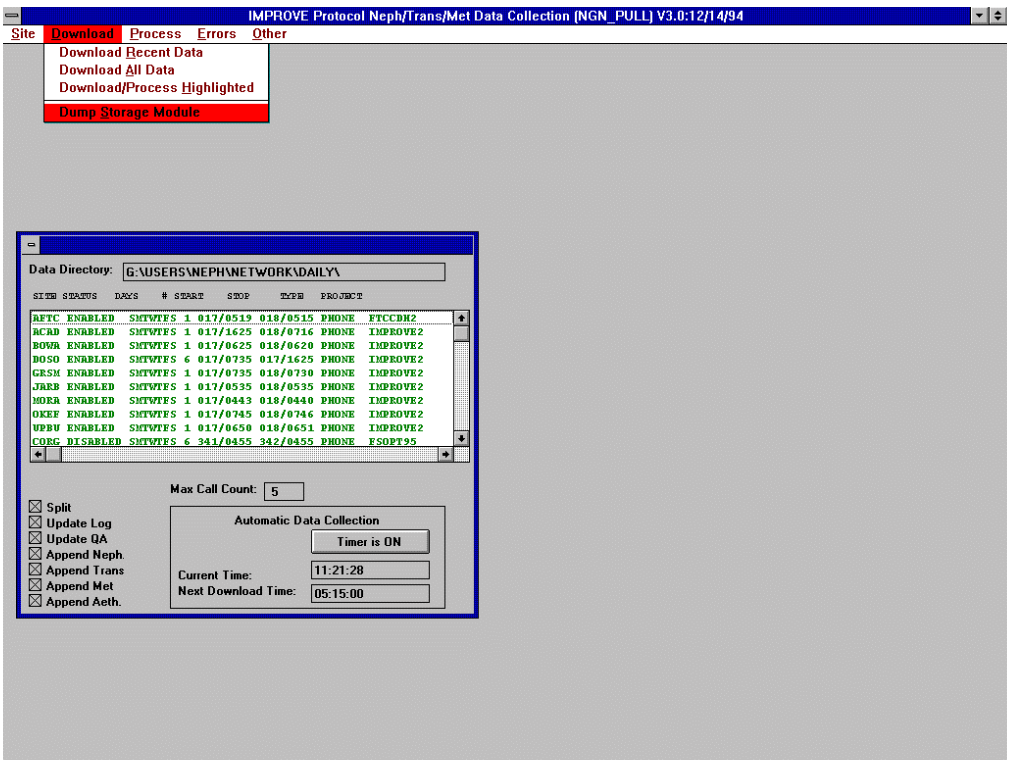

Figure 4-1. NGN_PULL Windows Program Screen.

- Plot title

- DCP station ID and GMT time offset (if applicable)

The list may be edited by clicking **SITE** from the menu bar and then selecting **EDIT**, **ADD**, or **DELETE**. A site can be disabled (from calling) or enabled (to call) by clicking **SITE** from the menu bar and selecting **DISABLE** or **ENABLE**.

Telephone-type stations have a corresponding station definition file (XXXX.STN) that the TELCOM program uses for datalogger and modem-specific parameters (including the telephone number). The following procedures are used to add, edit, or remove a site from the station list.

<u>To add a new site</u>:

- Click **SITE** from the menu bar and select **ADD**.

- Complete the fields in the "Edit Site Information" dialog box.

- Click **OK**.

<u>To edit an existing site</u>:

- Highlight the site to edit in the site list box.

- Click **SITE** from the menu bar.

- Click **EDIT**.

- Complete the "Edit Site Information" dialog box.

- Click **OK**.

- Set the following parameters in the station definition file:

  - Type of datalogger (21X)

  - Type of data file

  - Modem type, COM port, and baud rate

  - Telephone number

<u>To remove a site</u>:

- Highlight the site to remove in the site list box.

- Click **SITE** from the menu bar.

- Click **DELETE**.

USING THE SC532 STORAGE MODULE INTERFACE

The Campbell Scientific SC532 Storage Module Interface provides the means for the computer RS232 serial port to communicate with the storage module. The SC532 attaches to one of the PC's serial ports (COM1-4) via the 23-pin connector. The 9-pin connector attaches to the storage module. The SC532 is powered by its own AC power adapter. Consult the user's manual or hardware manual for the PC being used for information on the PC's serial COM ports.

DOWNLOADING THE STORAGE MODULE

Data in the storage module are downloaded using the Campbell Scientific SMCOM program. The SMCOM program provides the means to download the data, set storage module parameters, clear the storage module, and store or retrieve datalogger programs in the storage module. The following procedures describe downloading data from the storage module:

- Run the NGN_PULL program.
- Click **DOWNLOAD** from the menu bar and then **DUMP STORAGE MODULE** to start the SMCOM program.
- Click **DUMP** from the menu bar to bring up the SMCOM program opening screen.
- Select the COM port that the SC532 interface is attached to (see Figure 4-2).
- Select **A** to collect all data files from the storage module (see Figure 4-3).
- Enter the four-character site abbreviation when prompted for the file name (see Figure 4-3).
- Select **D** to download the data into printable ASCII format (see Figure 4-4).
- The raw storage module file will be named "XXXXYYSM.JJJ," where "XXXX" is the site abbreviation, "YY" is the year, and "JJJ" is the Julian date.

EXAMINE THE DAILY NEPHELOMETER ERROR FILES

Daily nephelometer error files contain details about the success of the datalogger interrogation and operation of the nephelometer station. This information is contained in the downloaded data file and is extracted automatically during daily data processing. The following error files are created:

- NGNYYJJJ.ERR
  A telcom error file that includes problems connecting with the on-site datalogger.

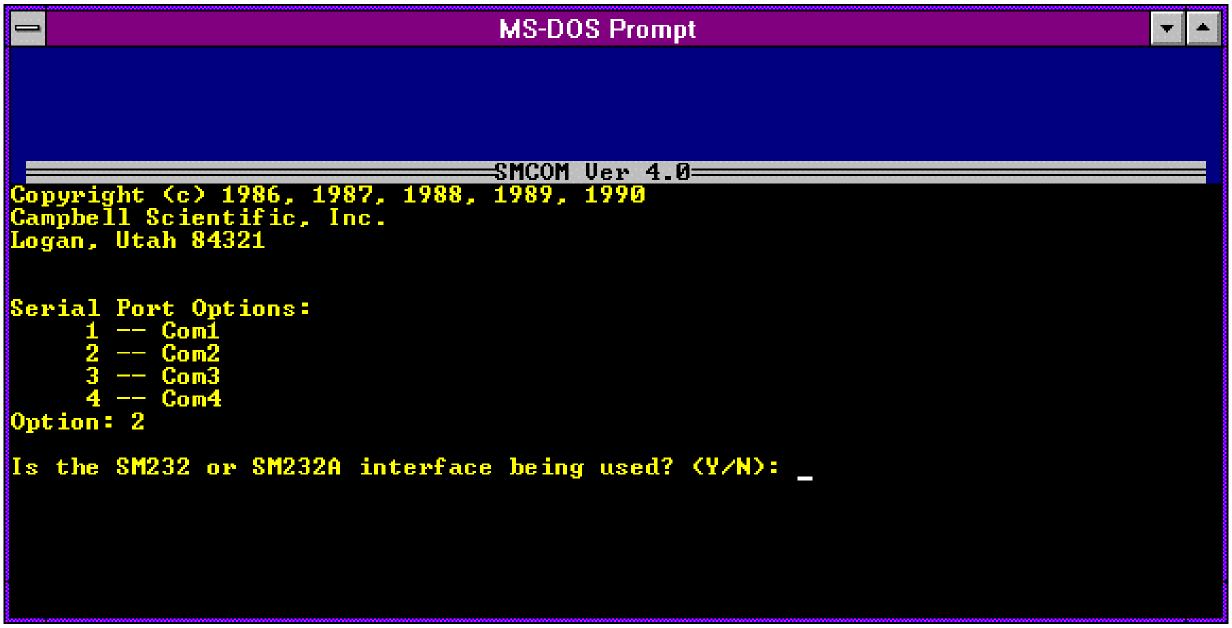

Figure 4-2. Campbell Scientific SMCOM Program Opening Screen.

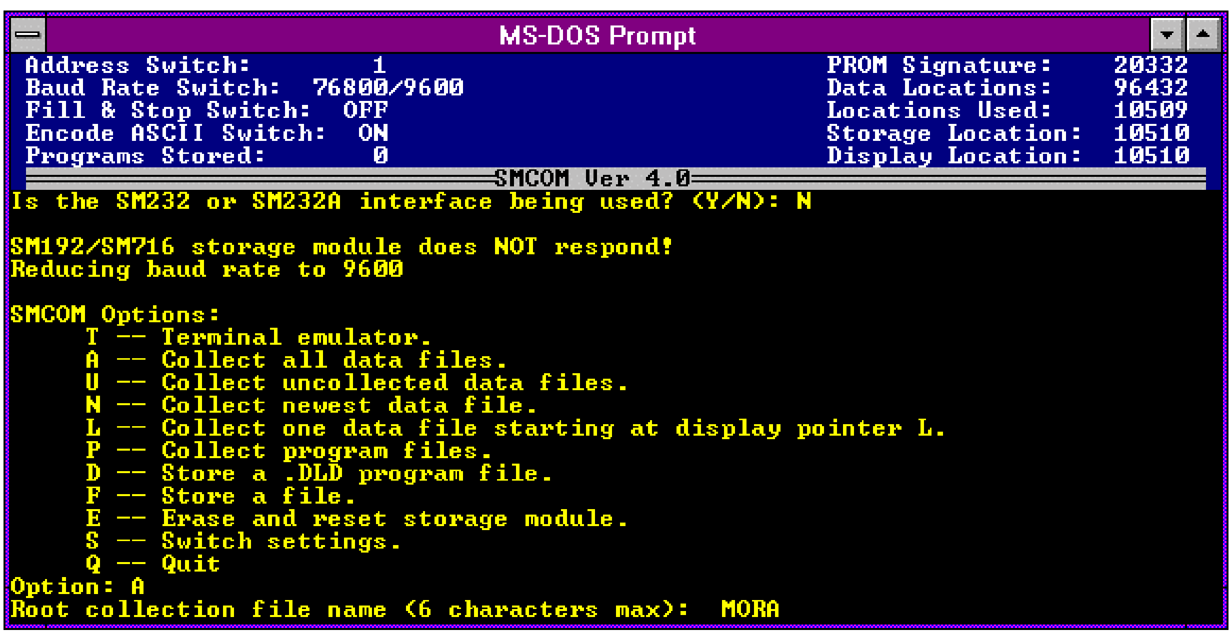

Figure 4-3. Campbell Scientific SMCOM Program Option Screen.

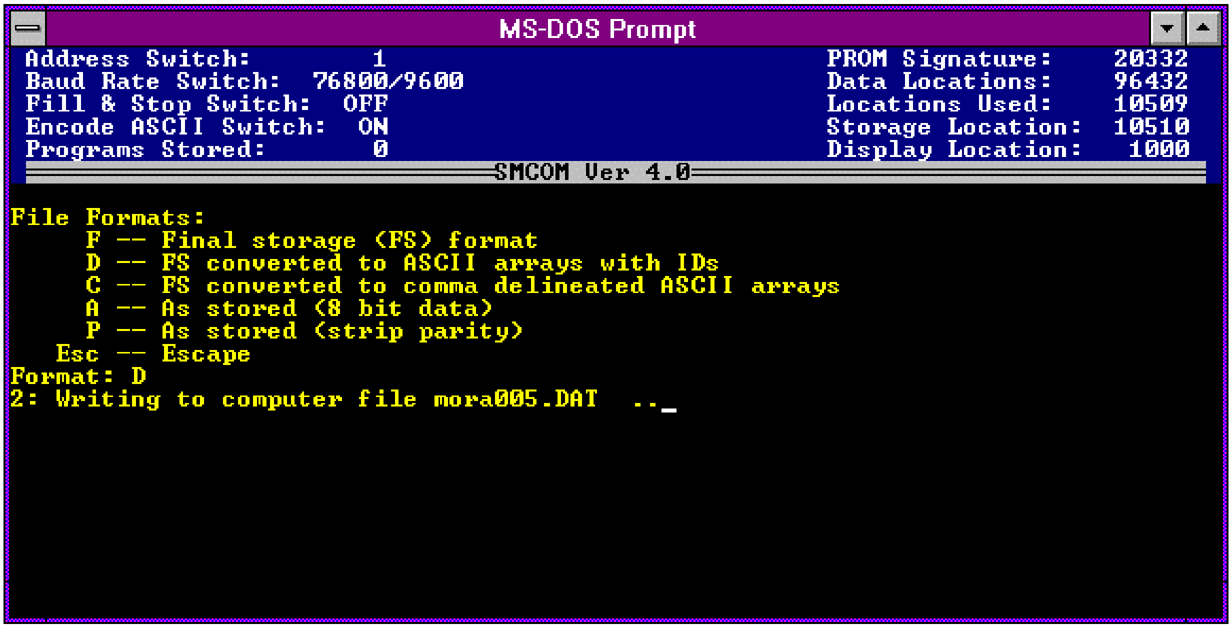

Figure 4-4. Campbell Scientific SMCOM Program File Format Screen.

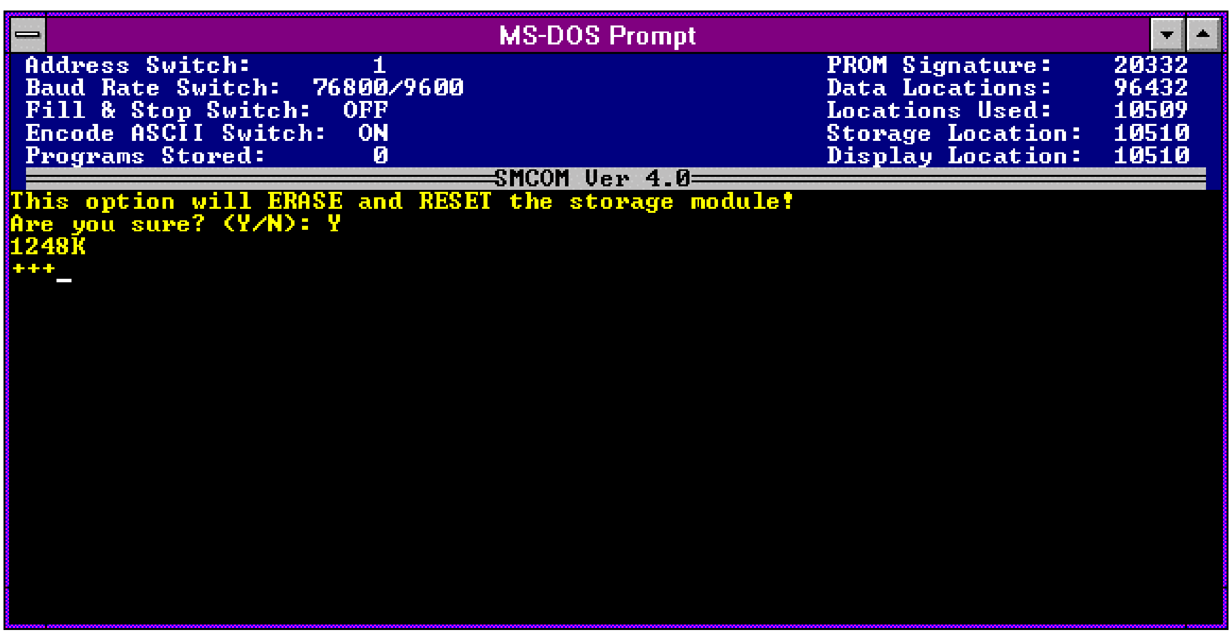

Figure 4-5. Campbell Scientific SMCOM Program Storage Module Clear and Reset.

- NGNYYJJJ.INF
  A nephelometer system error file that includes non-ambient nephelometer occurrences (calibrations, rain, etc.) and problems with AC and DC power levels.

- NGNYYJJJ.PER
  A processing error file that includes processing problems of the raw data file.

Note: "YY" is the year and "JJJ" is the Julian date in these files.

The error files can be viewed as follows:

- Click **ERRORS** on the menu bar.

- Click one of the error files to view:

  - View **TELCOM** Errors

  - View **NEPHELOMETER** Errors

  - View **PROCESSING** Errors

- The error file will be loaded into Microsoft Notepad for viewing.

Figure 4-6 displays examples of the three error files. The data coordinator will review the daily error files and note problems requiring corrective actions. If required, the corrective actions highlighted in Table 4-1 will be implemented by the data coordinator as described in TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*.

PROCESS STORAGE MODULE DATA

The downloaded storage module data file is processed as follows:

- Highlight the station to process in the station list.

- Click **PROCESS** on the menu bar.

- Click **PROCESS PHONE/SM**.

- A file selection dialog box will appear. Highlight the raw data file to process in the dialog box.

- Click **OK** on the menu bar.

Example Telcom Error File

```
TELCOM error at SHRO: 01/13/95 06:02:33 Smartmodem did not detect carrier!
TELCOM error at SHRO: 01/13/95 06:03:24 Smartmodem did not detect carrier!
TELCOM error at SHRO: 01/13/95 06:04:14 Smartmodem did not detect carrier!
TELCOM error at SHRO: 01/13/95 06:05:05 Smartmodem did not detect carrier!
TELCOM error at SHRO: 01/13/95 06:05:56 Smartmodem did not detect carrier!
TELCOM error at SHRO: 01/13/95 06:06:47 Smartmodem did not detect carrier!
TELCOM error at SEWZ: 01/13/95 06:30:20 Warning: 1 retries were logged.
TELCOM error at JUNZ: 01/13/95 06:39:22 Smartmodem did not detect carrier!
```

Example Nephelometer System Error File

```
=======================================================
==                  ACAD                             ==
=======================================================
SERIAL DATA: 1995  12  1447  3  49  2039  48  10  2.02  1  1433  49.42  2991  .748  95.6
SERIAL DATA: 1995  12  1448  5  152  .92  48  10  2.02  1  1433  49.42  4986  .817  95.5
RAIN EVENT       ( 1050 )  DATE: 1995  12 TIME: 1500
ZERO             ( 1150 )  DATE: 1995  12 TIME: 1600
BLUE EARTH RESET ( 2000 )  DATE: 1995  12 TIME: 2000

=======================================================
==                  BOWA                             ==
=======================================================
SERIAL DATA: 1995  12  700  2  129  3006  85  10 -2.31  1  647  87.3  1998 -4.222  92.2
ZERO             ( 150 )  DATE: 1995  12 TIME: 800
SERIAL DATA: 1995  12  1320  2  137  3023  90  10 -1.11  1  1307  92.1  1998 -2.71  93
ZERO             ( 150 )  DATE: 1995  12 TIME: 1400
SERIAL DATA: 1995  12  1940  2  161  3017  106  10 -2.11  1  1927  107.2  1998 -3.741  92.7
ZERO             ( 150 )  DATE: 1995  12 TIME: 2000
SERIAL DATA: 1995  13  25  5  217  .92  187  2 -4.48  1  20  187  4992 -5.73  91.2
```

Example Processing Error File

```
TRANSGETSITE: No lamp file! F:\USERS\SITE.CON\MACA_L
TRANSGETSITE: No lamp file! F:\USERS\SITE.CON\LOPE_L
TRANSGETSITE: No lamp file! F:\USERS\SITE.CON\SEWZ_L
VORZ: Suspect analog A2=-294.3)  JD= 12 TIME= 1605
VORZ: Suspect analog A2=-128.3)  JD= 12 TIME= 1610
TRANSGETSITE: No lamp file! F:\USERS\SITE.CON\VORZ_L
TRANSGETSITE: No lamp file! F:\USERS\SITE.CON\VORZ_L
```

Figure 4-6. Example Nephelometer Error Files Generated by NGN_PULL.

Table 4-1

Nephelometer Data Collection
Corrective Actions

Daily Nephelometer Information File			Corrective Action
Status Code	Site Abbrv.	Date/Time	
CHOPPER FAILURE	(xxxx)	DATE: 1993 063 TIME: 13:55	Reset nephelometer via phone modem or contact site operator.
RAIN EVENT	(xxxx)	DATE: 1993 063 TIME: 13:55	None required.
LAMP OUT	(xxxx)	DATE: 1993 063 TIME: 13:55	Have site operator change lamp.
SPAN	(xxxx)	DATE: 1993 063 TIME: 13:55	Enter span value in site-specific calibration file.
ZERO	(xxxx)	DATE: 1993 063 TIME: 13:55	None required.
BUFFER RESET	(xxxx)	DATE: 1993 063 TIME: 13:55	None required.
AC POWER OUT	(xxxx)	DATE: 1993 063 TIME: 13:55	Have site operator check support system AC fuse and main circuit breaker.
DC POWER LOW	(xxxx)	DATE: 1993 063 TIME: 13:55	Have site operator check support system DC fuse.
21X POWER LOW	(xxxx)	DATE: 1993 063 TIME: 13:55	None required.

4.2 FILE NAMES AND CONTENTS

4.2.1 Data Collection and Processing Files

Compilation and processing of nephelometer data involves several files. The following describes the processing steps and files used:

- Data for individual nephelometer stations are downloaded from the storage module into site-specific data files. The file name is of the form "XXXXYYSN.JJJ," where "XXXX" is the site abbreviation, "YY" is the year, "N" is a character from A through 9, and "JJJ" is the Julian date. These files contain all data collected by the datalogger.

- Data in the site-specific files are divided into several instrument-specific temporary data files. Five-minute nephelometer and meteorological data are placed in "XXXX.NEP," hourly code summary information is placed in "XXXX.INF," and hourly meteorological data are placed in "XXXX.FSM."

- The 5-minute nephelometer and hourly meteorological data in the temporary files (XXXX.NEP) are appended to the following site-specific Level-A files:

  Nephelometer: XXXX_N.YYS

  Meteorological: XXXX_M.YYS

  ("XXXX" is the site abbreviation, "YY" is the year, and "S" is the season code)

- Hourly code summary data are formatted and written to the daily nephelometer error file.

- Level-A files may be examined or plotted. These files serve as the initial files for further processing as detailed in TI 4400-5010, *Nephelometer Data Reduction and Validation (IMPROVE Protocol)*. Level-A files are maintained as active on the system hard disk until completion of seasonal processing.

- Other files used by NGN_PULL include:

  NGN_SITE.LST A list of active sites that appear in the site list window of NGN_PULL

  NGN_FILE.LST A list of raw data file names already in use by NGN_PULL

4.2.2 Site-Specific Data File Description

The site-specific raw storage module file consists of the following sets of data:

- Five-minute data synchronized to the 21X datalogger clock including nephelometer analog channels A1 and A2, ambient temperature, and relative humidity. The format is:

5-Minute Analog Data

01+0163. 02+1993. 03+0059. 04+0755. 05+582.6 06+0999. 07+2.234 08+097.1

Element #	Description
01	Datalogger program location identifier (not used)
02	Year
03	Julian date
04	Time (HHMM) at the end of the data period
05	Nephelometer A1 channel (mV x 2.0)
06	Nephelometer A2 channel (mV x 2.0)
07	Ambient air temperature (°C)
08	Ambient relative humidity (%)

- Five-minute data output when the nephelometer provides a serial data stream, including nephelometer serial data, analog channels A1 and A2, ambient temperature, and relative humidity. The format is:

5-Minute Serial

01+0119. 02+1993. 03+0059. 04+0757. 05+1.000 06+0891. 07+3493. 08+510.0
09+2.000 10+3.510 11+2.000 12+0755. 13+509.3 14+0999. 15+2.456 16+097.1

Element #	Description
01	Datalogger program location identifier (not used)
02	Year
03	Julian date
04	Time (HHMM) the serial stream was received by the datalogger
05	Nephelometer status code
06	Nephelometer raw scattered light reading (counts)
07	Nephelometer direct light reading (counts)
08	Nephelometer normalized scattered light reading (counts)
09	Nephelometer integration time (minutes)
10	Nephelometer chamber temperature (°C)
11	Not used
12	Nephelometer time (HHMM)
13	Nephelometer A1 channel (mV x 2.0)
14	Nephelometer A2 channel (mV x 2.0)
15	Ambient air temperature (°C)
16	Ambient relative humidity (%)

- Hourly code summary for the nephelometer and support system. The format is:

Hourly Code Summary

01+0104. 02+1993. 03+0059. 04+0800. 05+50.00 06+0.000

Element #	Description
01	Datalogger program location identifier (not used)
02	Year
03	Julian date
04	Time (HHMM) at the end of the data period
05	Nephelometer code summary for the past hour
06	Support system code summary for the past hour

The nephelometer code summary is the sum of any or all of the following:

50	Ambient reading
100	Clean air calibration
300	Span calibration
500	Lamp burned out
1000	Precipitation event detected
2000	Chopper motor start-up failure

The support system code summary is the sum of any or all of the following:

300	21X datalogger power low
500	DC power supply voltage low
1000	AC power outage
2000	Blue Earth serial data buffer restarted

- Hourly average meteorological data including wind speed, wind direction, ambient temperature, and relative humidity. The format is:

Hourly Meteorological Data

01+0171. 02+1995. 03+0013. 04+0700. 05-3.765 06+090.2 07+6.975 08+312.9 09+13.67

Element #	Description
01	Datalogger program location identifier (not used)
02	Year
03	Julian date
04	Time (HHMM) at the end of the data period
05	Ambient temperature (°F)
06	Relative humidity (%)
07	Wind speed (mph)
08	Wind direction (degrees true)

4.3.3 Level-A Nephelometer File Description

The level-A nephelometer file is a formatted ASCII site-specific file. A key to the Level-A file format is presented in Figure 4-7.

4.3.4 Level-A Meteorological File Description

The level-A meteorological file is a formatted ASCII site-specific file. A key to the Level-A file format is presented in Figure 4-8.

5.0 REFERENCES

Campbell Scientific, Inc., 1989, Campbell Scientific PC208 Datalogger Support Software Instruction Manual, February.

Microsoft Corporation, 1992, Microsoft Windows 3.1 User's Guide.

Field

```
  1      2     3   4     5     6        7        8      9       10       11      12      13       14
< 10 line informational header at start of file >
VORZ 941228 362 0110  10  212.17  212.60 -99.00 -99.00 -99.000  -5.68  -5.44  83.10   3912
VORZ 941228 362 0115  10  209.77  207.90 -99.00 -99.00 -99.000  -5.74  -5.37  83.20   3909
VORZ 941228 362 0120  10  210.58  209.90 -99.00 -99.00 -99.000  -5.74  -5.51  83.30   3913
```

Field #	Description
1	Site abbreviation
2	Year, month , day (YYMMDD)
3	Julian date (JJJ)
4	Time (HHMM)
5	Code summary (3-characters) 1: Power code (non-space character = power problem) 2: Nephelometer status code 1 = ambient 2 = zero 3 = span 4 = lamp 5 = rain 6 = chopper 3: Nephelometer data type code 0 = serial 1 = analog 2 = DCP
6	Nephelometer serial or analog normalized reading (counts)
7	Nephelometer serial normalized reading calculated from the raw readings (counts)
8-10	Not used
11	Chamber temperature (°C)
12	Ambient air temperature (°C)
13	Ambient relative humidity (%)
14	Raw lamp brightness (counts)

Figure 4-7. Key to the Level-A Nephelometer File Format.

Field

1	2	3	4	5	6	7	8	9
CORG	941201	335	0000	50.30	69.12	17.36	273.00	12.27
CORG	941201	335	0100	49.27	73.80	14.20	268.80	34.81
CORG	941201	335	0200	49.51	74.30	14.98	275.60	8.25

Field #	Description
1	Site abbreviation
2	Year, month , day (YYMMDD)
3	Julian date (JJJ)
4	Time (HHMM), hour ending
5	Hourly average ambient air temperature (°F)
6	Hourly average ambient relative humidity (%)
7	Hourly average wind speed (mph)
8	Hourly average wind direction (degrees true)
9	Hourly standard deviation wind direction (degrees)

Figure 4-8. Key to the Level-A Meteorological File Format.

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1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 303-484-7941
Fax: 303-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
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AUTHORIZATIONS

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REVISION HISTORY

REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the reduction and validation of Optec NGN-2 nephelometer and collocated meteorological data according to IMPROVE Protocol.

The Optec NGN-2 nephelometer measures the atmospheric scattering coefficient (b_{scat}) of total atmospheric extinction (b_{ext}). The raw nephelometer output is converted to b_{scat} using instrument and time-specific calibration information.

This TI is a guide to the reduction and validation of nephelometer and collocated meteorological data. Data reduction and validation begin with the daily interrogation of the on-site datalogger and end with Level-1 validated nephelometer and meteorological data. Nephelometer and meteorological data undergo the following reduction and validation steps:

- Daily collection and review
- Daily and weekly Level-A data validation and review
- Seasonal Level-0 data validation
- Seasonal Level-1 data validation and review

This TI describes the validation of the following nephelometer and meteorological parameters:

- Atmospheric scattering coefficient (b_{scat})
- Nephelometer chamber temperature
- Ambient temperature
- Ambient relative humidity

Because most stations are remote, daily review of raw and Level-A validated data are critical to the identification and resolution of problems. Level-1 validated nephelometer data are used for reporting and further analyses.

2.0 RESPONSIBILITIES

2.1 PROGRAM MANAGER

The program manager shall:

- Review Level-1 validated data with the project manager to ensure quality and accurate data validation.
- Coordinate data reduction and validation goals, objectives, and methods with the Contracting Officer's Technical Representative (COTR) to ensure that data validation procedures meet the IMPROVE program requirements.

2.2 PROJECT MANAGER

The project manager shall:

- Review and verify calibration data for each instrument.

- Review Level-1 validated data with the program manager, data coordinator and field specialist.

2.3 DATA COORDINATOR

The data coordinator shall:

- Perform data validation procedures described in this technical instruction.

- Resolve data validation problems with the project manager.

- Identify instrument or data collection and validation problems and initiate corrective actions.

2.4 FIELD SPECIALIST

The field specialist shall review raw and validated data with project manager and data coordinator to resolve instrument problems.

3.0 REQUIRED EQUIPMENT AND MATERIALS

All data reduction and validation occurs on IBM-PC compatible computer systems. The required computer system components include:

- IBM compatible 386/486 computer system with VGA, 80 megabyte hard disk, 8 megabyte RAM

- Microsoft Windows 3.1 and Compatible Printer

- Latest versions of the following software for performing data collection, Level-A validation, and plot review:

  - NGN_PULL.EXE and NGN_PLOT.EXE

- Latest version of software for performing Level-0 and Level-1 validation and Quality Assurance (QA) file summaries:

  - NGN_SEAS.EXE and NGN_QA.EXE

- Latest version of software for generating nephelometer seasonal summary plots:

  - NGN_NSUM.EXE

4.0 METHODS

Data reduction and validation begin with the daily interrogation of the on-site datalogger and end with Level-1 validated nephelometer and associated meteorological data.

This section includes six (6) subsections:

4.1 Daily Collection of Nephelometer and Meteorological Data
4.2 Daily and Weekly Level-A Validation of Nephelometer and Meteorological Data
4.3 Seasonal Update of Quality Assurance (QA) Database (XXXX_C) Files
4.4 Seasonal Update of Quality Assurance (QA) Calibration Files
4.5 Seasonal Level-0 Validation of Nephelometer and Meteorological Data
4.6 Seasonal Level-1 Validation of Nephelometer and Meteorological Data

Figure 4-1 is a flowchart of the data reduction and validation procedures for nephelometer and collocated meteorological data. These procedures are described in the following subsections.

4.1 DAILY COLLECTION OF NEPHELOMETER AND METEOROLOGICAL DATA

Daily collection of raw nephelometer and meteorological data is handled by the NGN_PULL software. NGN_PULL automatically oversees the following tasks relating to daily data collection:

- On-site Campbell Scientific 21XL dataloggers are interrogated daily via telephone modem for all raw nephelometer and meteorological data available since the last download. Raw data collected via telephone modem are saved in daily site-specific ASCII files.

- At sites where telephone access is unavailable, preliminary nephelometer and meteorological data are extracted from satellite-telemetered DCP data. Preliminary DCP data are replaced by data collected via Campbell Scientific data storage module at regular intervals. Preliminary nephelometer and meteorological data collected via DCP are saved in daily ASCII DCP files with other DCP-collected optical data.

Refer to the following documentation for detailed data collection procedures:

- SOP 4300, Collection of Optical Monitoring Data

- TI 4300-4000, Data Collection via DCP

- TI 4300-4002, Nephelometer Data Collection via Telephone Modem

- TI 4300-4004, Nephelometer Daily Compilation and Review of DCP-Collected Data

- TI 4300-4006, Nephelometer Data Collection via Campbell Scientific Data Storage Module

- TI 4100-3300, Troubleshooting and Emergency Maintenance Procedures for Optec NGN-2 Nephelometer Systems

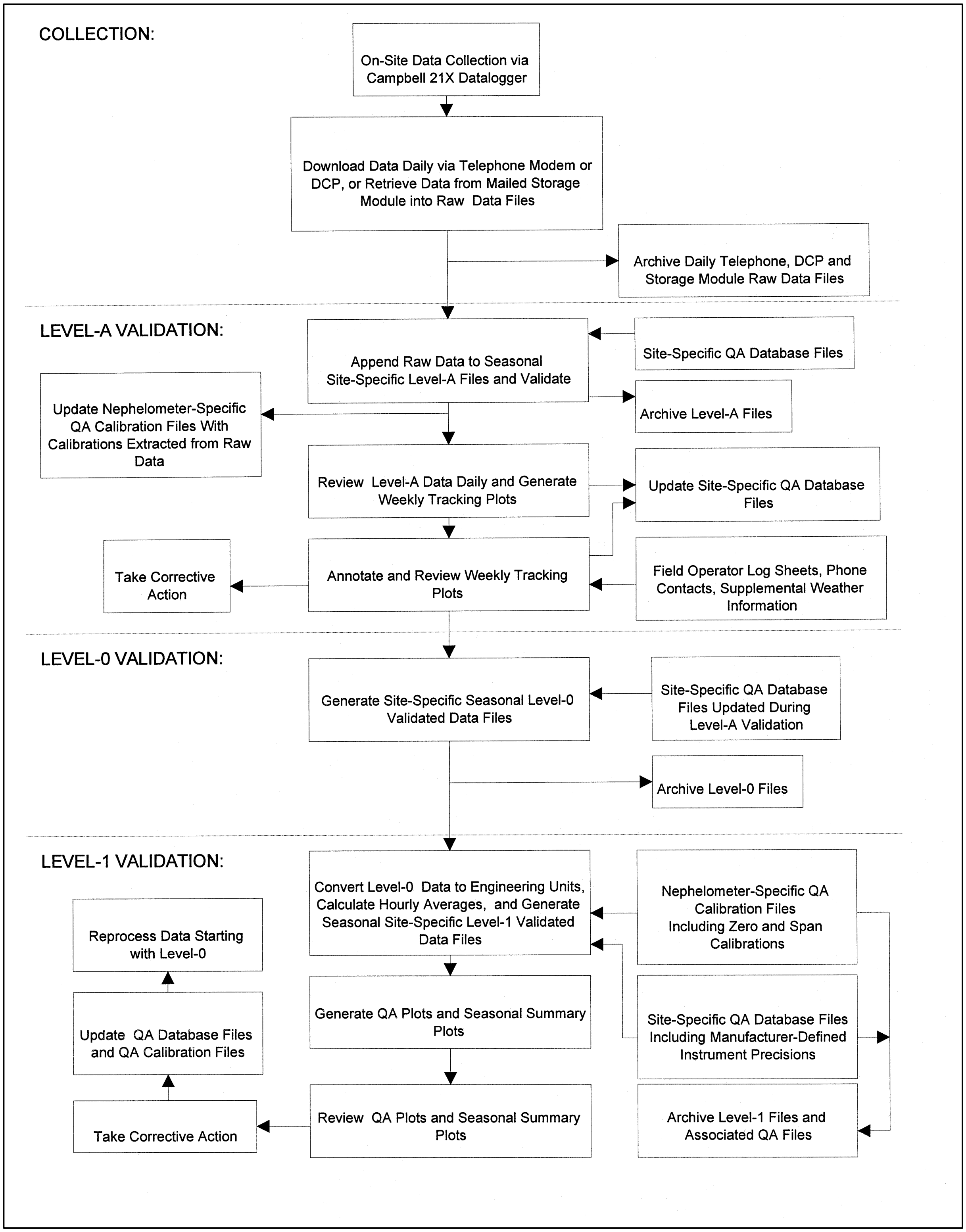

Figure 4-1. Nephelometer and Meteorological Data Reduction and Validation Flowchart.

Figures 4-2 and 4-3 present the file formats of raw data collected via telephone modem and DCP, respectively.

The data coordinator verifies that all data were collected. Any data collection problems are immediately reported to the project manager. Ongoing data collection problems are resolved according to TI 4100-3300, Troubleshooting and Emergency Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol).

4.2 DAILY AND WEEKLY LEVEL-A VALIDATION OF NEPHELOMETER AND METEOROLOGICAL DATA

Level-A validation of raw nephelometer and meteorological data includes:

- Daily automatic reformatting and Level-A validation by the NGN_PULL software
- Daily visual review of raw and Level-A data
- Weekly plotting and review of Level-A data

4.2.1 Daily Automatic Reformatting and Level-A Validation

Daily automatic reformatting and Level-A validation of raw nephelometer and meteorological data by NGN_PULL occurs immediately after collection and is detailed in the documentation listed above. The tasks the NGN_PULL software performs are:

- The following parameters are extracted from the raw telephone-modem or DCP daily data file and appended to site-specific seasonal data files:
  - Serial nephelometer raw scattered light (counts)
  - Serial nephelometer direct light (counts)
  - Serial nephelometer chamber temperature (°C)
  - Serial nephelometer status code (1-9)
  - Analog nephelometer normalized scattered light (1 mVDC = 1 count)
  - Analog status code (1 VDC = code 1)
  - Ambient temperature (°C)
  - Relative Humidity (%)
  - AC and DC power failure information
- Automatic clean air zero calibrations and operator-initiated clean air zero and span calibrations recorded by the datalogger are extracted from the raw data file and appended to nephelometer-specific QA calibration files. Figure 4-4 shows a sample nephelometer-specific QA calibration file.

```
5-Minute Analog Data
01+0163.  02+1993.  03+0059.  04+0755.  05+582.6  06+0999.  07+2.234  08+097.1
```

Element #	Description
01	Datalogger program location identifier (not used)
02	Year
03	Julian date
04	Time (HHMM) at the end of the data period
05	Nephelometer A1 channel (mV x 2.0)
06	Nephelometer A2 channel (mV x 2.0)
07	Ambient air temperature (°C)
08	Ambient relative humidity (%)

```
5-Minute Serial
01+0119.  02+1993.  03+0059.  04+0757.  05+1.000  06+0891.  07+3493.  08+510.0
09+2.000  10+3.510  11+2.000  12+0755.  13+509.3  14+0999.  15+2.456  16+097.1
```

Element #	Description
01	Datalogger program location identifier (not used)
02	Year
03	Julian date
04	Time (HHMM) the serial stream was received by the datalogger
05	Nephelometer status code
06	Nephelometer raw scattered light reading (counts)
07	Nephelometer direct light reading (counts)
08	Nephelometer normalized scattered light reading (counts)
09	Nephelometer integration time (minutes)
10	Nephelometer chamber temperature (°C)
11	Not used
12	Nephelometer time (HHMM)
13	Nephelometer A1 channel (mV x 2.0)
14	Nephelometer A2 channel (mV x 2.0)
15	Ambient air temperature (°C)
16	Ambient relative humidity (%)

```
Hourly Code  Summary
01+0104.  02+1993.  03+0059.  04+0800.  05+50.00  06+0.000
```

Element #	Description
01	Datalogger program location identifier (not used)
02	Year
03	Julian date
04	Time (HHMM) at the end of the data period
05	Nephelometer code summary for the past hour
06	Support system code summary for the past hour

The nephelometer code summary is the sum of any or all of the following:

Code	Description
50	Ambient reading
100	Clean air calibration
300	Span calibration
500	Lamp burned out
1000	Precipitation event detected
2000	Chopper motor start-up failure

The support system code summary is the sum of any or all of the following:

Code	Description
300	21X datalogger power low
500	DC power supply voltage low
1000	AC power outage
2000	Blue Earth serial data buffer restarted

Figure 4-2. Raw Telephone-Modem or Campbell Scientific Data Storage Module Data File Format.

```
Example Data                                                  Description
FA40643E93085122318G43-1NN002W4C00432             Identification and quality
# 1  1716
# 2   114   173   210   224   383   407   297   302
# 2   383   140   135   140   125   132   138   128
# 2   141   155
# 3   498   498   498   498   498   498   498   498
# 3   498   498   498   498   498   498   498   498
# 3   498   498
# 4   524   423   324
# 5    50    50    50
# 6    -1    -1    -1
# 7   209   209   209
# 8  1020  1020  1020
# 9    96    92   102
#10   960   954   926
#11  1388
```

Data Group Number	Description
#1	Synergetics DCP operation status
#2	10-minute nephelometer analog A1 readings (mV / 2)
#3	10-minute nephelometer analog A2 readings (mV / 2)
#4	Nephelometer time when 21X datalogger time is xx:30
#5	Hourly nephelometer code summary
#6	Hourly support code summary
#7	Last clean air calibration (counts) (x10)
#8	Last span calibration (counts) (x10)
#9	Ambient temperature at top of hour (°C) (x10)
#10	Ambient relative humidity at top of hour (%) (x10)
#11	DCP battery voltage (VDC) (x100)

Identification and transmission quality:

Characters	Example	Description
1-8	FA40643E	DCP identification
9-10	93	Year of transmission
11-13	085	Julian date of transmission
14-15	12	Hour of transmission
16-17	23	Minute of transmission
18-19	18	Second of transmission
20	G	Failure code
21-22	43	Signal strength
23-24	-1	Modulation frequency deviation from normal
25	N	Modulation quality
26	N	Modulation index
27-29	002	Satellite channel
30	W	Satellite (East or West)
31-32	4C	IFPD (Intermediate Frequency Presence Detector)
33-37	00432	Message length

Figure 4-3. Synergetics DCP Telemetered Data File Format.

```
BOWA                        Site Code
NGN-2-21                    Nephelometer Identification
Number 2                    Nephelometer Operational Cycle Number
37                          Initial Clean Air Calibration
106                         Initial Span Calibration
30,50,50,0,500              Zero Calibration Validation Parameters:
                            - Window size(30 days)
                            - Maximum Distance from Mean (50 counts)
                            -  Maximum  Distance  from  Linear  Regression
Line
                              (50 counts)
                            - Absolute Minimum (20 counts)
                            - Absolute Maximum (500 counts)
----------                  Comment (not used)
----------                  Comment (not used)
----------                  Comment (not used)

01-18-1994 07:15:11         Date and Time of Last Update
93,124,1420,-099.00,0037.05,022.46,023.92,019.78,1,Comment
93,124,1445,-099.00,0106.06,022.37,024.07,021.06,A,Comment
93,124,1500,0037.26,-099.00,022.03,024.16,019.07,I,Comment

                     Field Number
----------------------------------------------------------
1   2   3      4       5      6      7      8    9    10
```

Field #	Description
1	Year
2	Julian Date
3	Time (HHMM)
4	Clean Air Calibration or -99 (Counts)
5	Span Calibration or -99 (Counts)
6	Ambient Temperature (°C)
7	Nephelometer Chamber Temperature (°C)
8	Relative Humidity (%)
9	Validity Code (1= Valid serial , A=Analog, Other = Invalid)
10	Comment (No commas allowed in comment)

Figure 4-4. Example Nephelometer QA Calibration File.

- Three Level-A validity codes, generated by the datalogger and nephelometer, are extracted from the raw data and assigned to nephelometer data during the daily Level-A validation:

  - The ***Power Code***, generated by the datalogger, is an hourly summary of any AC or DC power problems that occurred during the previous hour.

  - The ***Nephelometer Status Code*** is generated by the nephelometer to indicate the type of measurement (ambient, clean air zero or span calibration) or problem (rain, lamp out, chopper motor failure).

  - The ***Data Type Code*** indicates the source of the nephelometer data (serial, analog, DCP).

- Meteorological data are not assigned Level-A validity codes. Meteorological parameter values that exceed the field sizes of the Level-A file are set to -99.

- Data at this point are at Level-A validation. Figure 4-5 shows an example Level-A validated data file and the associated validity codes for the parameters.

4.2.2 Daily Visual Review of Raw and Level-A Data

After Level-A validation by the NGN_PULL software, the data coordinator visually reviews the raw and Level-A data as follows:

- Raw and Level-A data file listings are visually reviewed daily to identify operational problems and initiate corrective procedures as soon as possible.

- Level-A validated data are plotted weekly using the NGN_PLOT software. The plots are posted and visually reviewed by the data coordinator, field specialist, and project manager. Comments regarding the operation of the nephelometer are noted on the plots. An example weekly plot is shown in Figure 4-6. If a new problem is identified beyond those discovered in the daily data review, corrective actions are initiated.

4.3 SEASONAL UPDATE OF QUALITY ASSURANCE (QA) DATABASE (XXXX_C) FILES

The QA database files are site-specific files containing the time-tagged operational history of each site. Specifically, each file includes:

- QA codes entered manually during Level-A validation, that identify periods as invalid

- Precision estimates for nephelometer and meteorological instrumentation

- QA calibration file names

- Rayleigh coefficient

```
NGN_PULL  V1.11:10/07/93  12-02-1993  06:11:47-------------------------------------------
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
ACAD 930701 182  000  11   84.52   85.00 -99.00 -99.00   0.059  13.35  13.30  80.70   2850
ACAD 930701 182  100  11   79.13   80.00 -99.00 -99.00   0.055  13.20  13.10  81.80   2795
ACAD 930701 182  200  11   69.22   70.00 -99.00 -99.00   0.047  13.41  13.30  81.00   2815

                                     Column Number
         1         2         3         4         5         6         7         8         9
123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Columns	Description
1-3	Site Abbreviation (four characters)
6-7	Year
8-9	Month
10-11	Day
13-15	Julian Date
17-18	Hour
19-20	Minute
22	Power Code (Space = No Power Failure)
23	Nephelometer Status Code (1-9)
24	Nephelometer Data Type Code (0 = Serial 1 = Analog 2 = DCP)
26-32	Nephelometer Serial Calculated Normalized Reading (Counts)
34-40	Nephelometer Analog Reading (1 mVDC = 1 Count)
42-47	Not Used
49-54	Not Used
56-62	Preliminary b_{scat} (km^{-1})
64-69	Nephelometer Chamber Temperature (°C)
71-76	Ambient Temperature (°C)
78-83	Relative Humidity (%)
85-90	Nephelometer Direct Light Intensity (Counts)

Figure 4-5. Level-A Validated Nephelometer Data File Format.

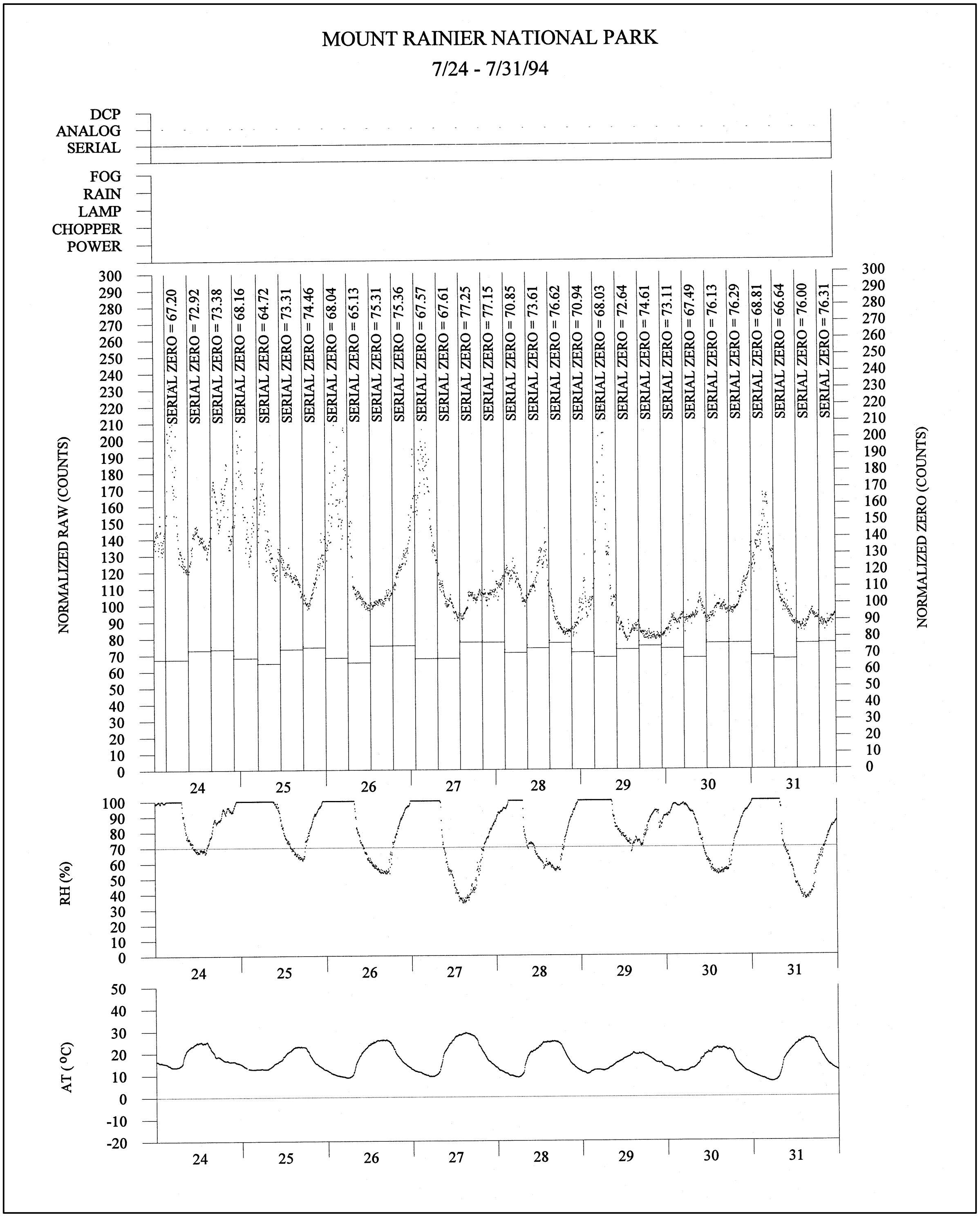

Figure 4-6. Example Weekly Plot of Level-A Validated Nephelometer and Meteorological Data.

Editing the QA database files is the only method of manually invalidating data. Seasonal updating of the QA database files includes:

- Filing log sheets
- Entering Level-A plot review information in the QA database files
- Editing the Rayleigh coefficient

Hardcopy log sheets are chronologically filed by site. Periods identified in the review of Level-A data as invalid are recorded in the site-specific QA database files, XXXX_C (where XXXX is the site code). The following codes are used in the site-specific QA database file:

1: Valid
x: Invalid (x = any other character)

Figure 4-7 shows an example QA Database Code file.

4.4 SEASONAL UPDATE OF QUALITY ASSURANCE (QA) CALIBRATION FILES

The QA calibration files are nephelometer-specific files containing all zero and span calibrations performed on a nephelometer during a specific time period, including the initial zero and span performed during installation. The calibration information in the QA calibration files are used during data reduction to calculate the scattering coefficient based on the nephelometer raw data and to estimate the precision of that data. The files also include parameters used by software to help identify invalid calibrations.

The QA calibration file names are defined in the site-specific QA database files. A new QA calibration file must be defined for the following reasons:

- New nephelometer installed at the site
- Significant change in the operation of the nephelometer as indicated by the raw data

There may be several QA calibration files defined each site-specific QA database file. This usually indicates that the nephelometer (or another nephelometer) has been installed more than once.

The seasonal update of QA calibration files includes the following:

- Update of QA file header information
- Generation of preliminary QA calibration plots and uncertainty estimates
- Review and manual validation of QA file entries
- Generation of final QA calibration plots and uncertainty estimates

```
Boundary Waters Canoe Area
Nephelometer Calibration File
01/13/94



-------------------------------------------------------------------------------------------------
YR   JD  TIME  LAMP NCODE N-PR CCODE CT-PR ACODE AT-PR RCODE RH-PR QA File  Comment

-------------------------------------------------------------------------------------------------
93, 124,  1630, 1,   1,   0.20, 1,    1.0,   1,    1.0,   1,    2.0,021_2.QA,
93, 229,  0845, 1,   1,   0.20, 1,    1.0,   1,    1.0,   1,    2.0,021_2.QA, new Blue Earth
93, 236,  0750, 2,   1,   0.20, 1,    1.0,   1,    1.0,   1,    2.0,021_2.QA, lamp change
93, 250,  0800, 2,   X,   0.20, 1,    1.0,   1,    1.0,   1,    2.0,021_2.QA, Surge: new modem.
93, 320,  1140, 3,   1,   0.20, 1,    1.0,   1,    1.0,   1,    2.0,021_2.QA, lamp change
93, 327,  0930, 3,   1,   0.20, 1,    1.0,   1,    1.0,   1,    2.0,021_2.QA, new light trap
```

Field	Description
YR	Year
JD	Julian Date
TIME	Time (HHMM)
LAMP	Lamp number
NCODE	Nephelometer validity code (1 = Valid, Other = Invalid)
N-PR	Nephelometer factory-defined precision (%, 0.20 = 20%)
CCODE	Chamber temperature validity code (1 = Valid, Other = Invalid)
CT-PR	Chamber temperature factory-defined precision (°C)
ACODE	Ambient temperature validity code (1 = Valid, Other = Invalid)
AT-PR	Ambient temperature factory-defined precision (°C)
RCODE	Relative humidity validity code (1 = Valid, Other = Invalid)
RH-PR	Relative humidity factory-defined precision (%)
QA FILE	Name of the QA calibration file in use
COMMENT	Comment - No commas allowed

Figure 4-7. Example Nephelometer QA Database File.

4.4.1 Update of QA Calibration File Header Information

Each QA file header must be updated manually to include correct information for the parameters detailed in Figure 4-4, including:

- Site, instrument number
- Initial zero and span calibration
- Zero calibration validation parameters

The QA file header can be edited using the NGN_SEAS software (described below) or using any ASCII text editor.

4.4.2 Generation of Preliminary QA Calibration Plots and Uncertainty Estimates

The data coordinator uses the NGN_QA software to generate preliminary QA calibration plots showing nephelometer zero and span calibrations recorded in the instrument-specific QA calibration files and an estimate of the precision of the nephelometer data based on those calibrations. The following procedures describe the operation of the NGN_QA software:

EXECUTE NGN_QA SOFTWARE	Execute the NGN_QA software from the Windows Program Manager. The NGN_QA display will appear as shown in Figure 4-8.
CHOOSE THE QA FILES TO PLOT	Highlight (click on) the QA files to plot. The QA calibrations will be plotted with at most one year of information per plot. The associated estimate of precision will be printed following the plot(s).
GENERATE THE PLOTS	The highlighted plots can be plotted to the screen or printer attached to the system. An example plot is shown in Figure 4-9 and an example uncertainty analyses is shown in Figure 4-10. The following procedures are used to generate the plots: • Choose the plot destination by clicking **Plot** and then **Screen** or **Printer**. • Generate the plots defined in the submit file by clicking **Plot** and then **GO!**

The NGN_QA software does not change the QA file in any way - it simply identifies which calibrations will be identified as invalid during Level-0 and Level-1 data validation.

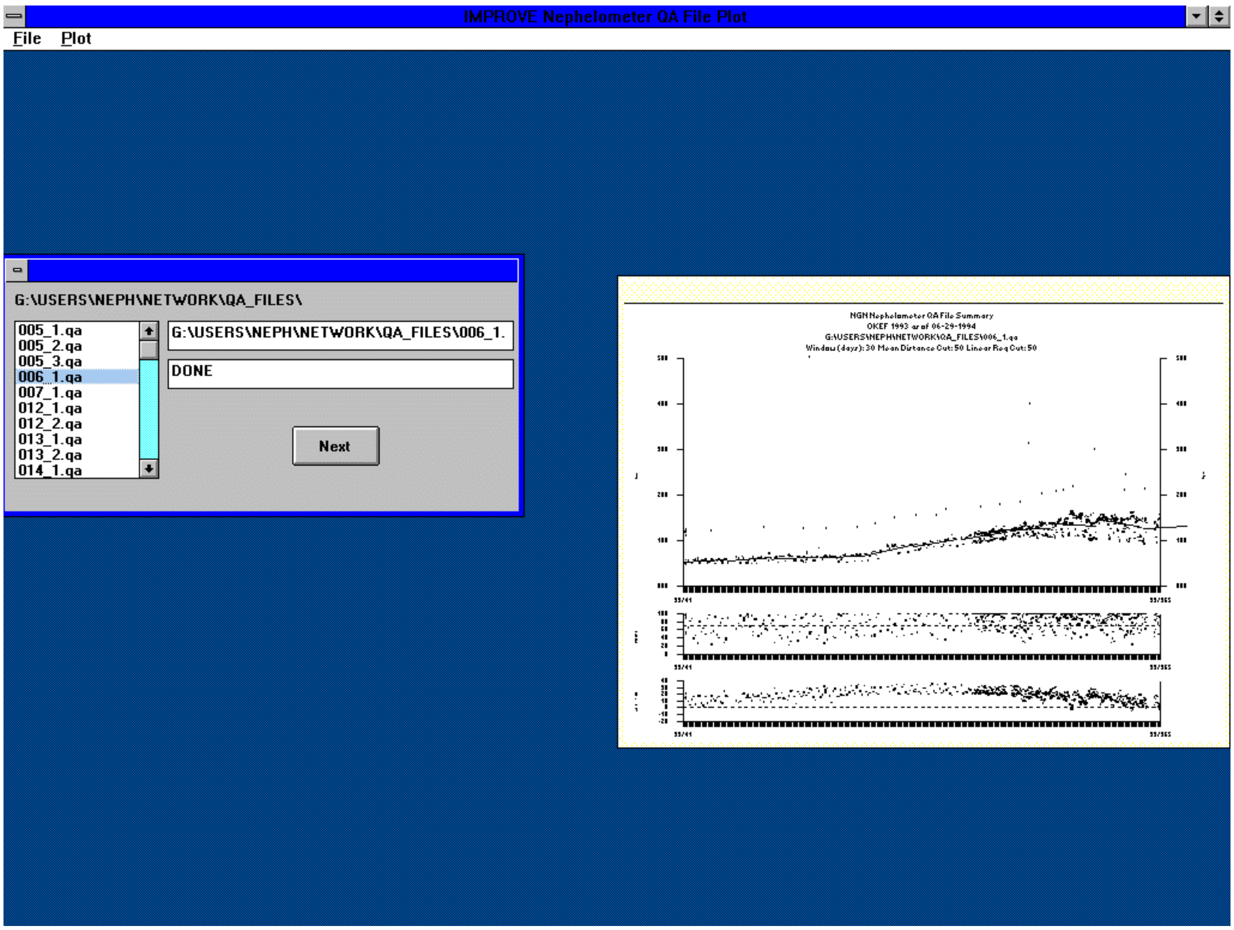

Figure 4-8. NGN_QA Software Display.

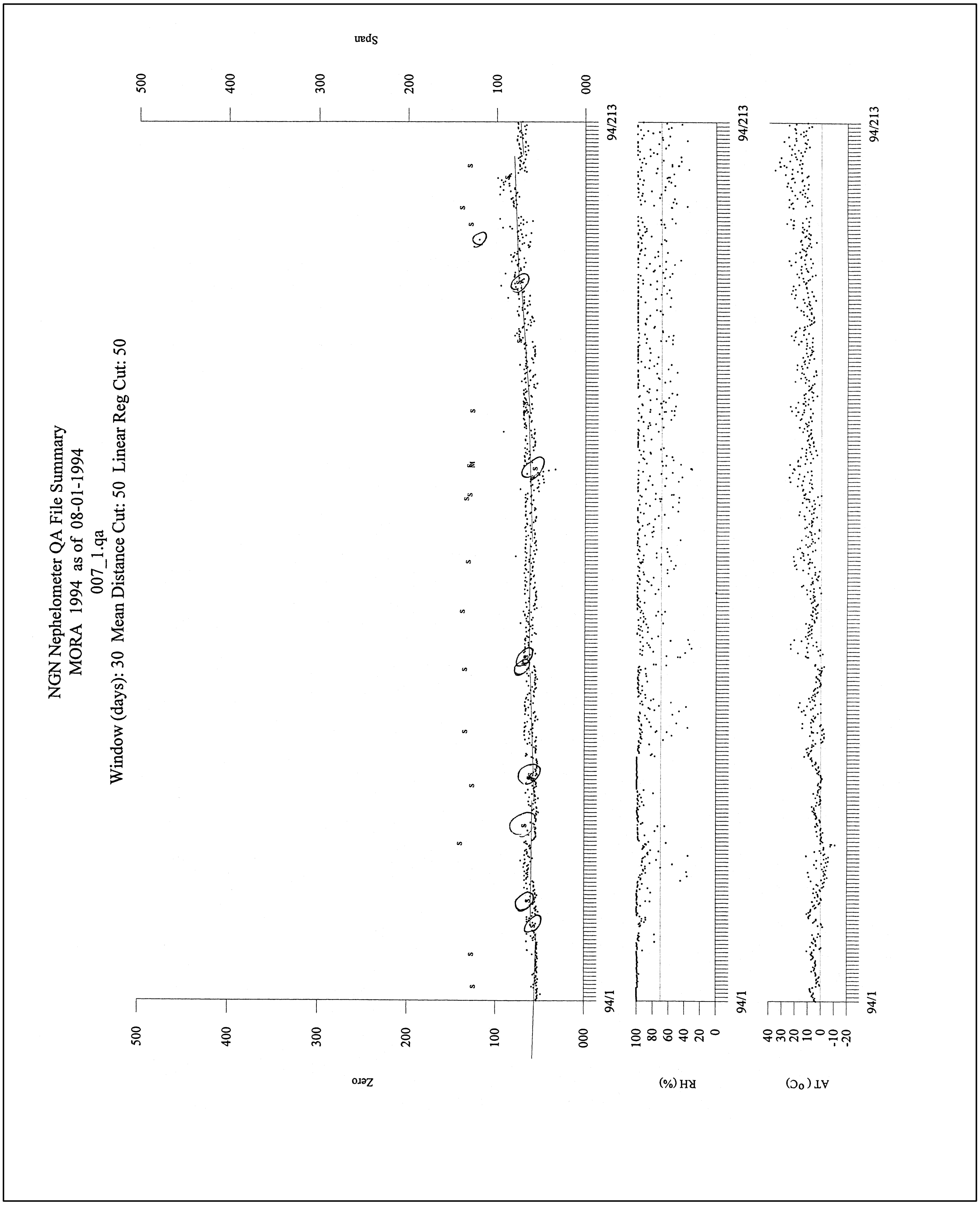

Figure 4-9. Example QA Calibration File Plot.

```
Nephelometer QA File Uncertainty Analysis - 07-31-1994
FILE: 007_1.qa

QA file header contents:
---------------------------------------------------------
MORA
NGN-2-07
Number 1
55.0
117.0
30,50,20
-----------
-----------
07-31-1994 05:34:57
YR  JD HHMM ZERO    SPAN    AT     CT     RH     C   COMMENT
---------------------------------------------------------

---------------------------------------------------------
Rayleigh (1/km)  (b,spo):  .01
Span (1/km) (b,spf):      0.071000
Initial Slope (m):        0.000984
---------------------------------------------------------

The following calibration checks were made:
YR/MM/DD  JD ZERO     SPAN     DIFF     SLOPE m(t)
---------------------------------------------------
93/02/08 039 0055.180 0117.550 0062.370 0000.000978
93/02/10 041 0051.130 0112.430 0061.300 0000.000995
93/02/10 041 0055.280 0116.880 0061.600 0000.000990
93/02/10 041 0055.310 0118.630 0063.320 0000.000963
93/02/11 042 0055.510 0119.540 0064.030 0000.000953
93/02/11 042 0053.950 0119.560 0065.610 0000.000930
93/02/11 042 0055.500 0114.350 0058.850 0000.001037
93/03/09 068 0057.820 0121.440 0063.620 0000.000959
93/04/06 096 0057.040 0123.600 0066.560 0000.000916
93/05/05 125 0060.240 0118.210 0057.970 0000.001052
93/05/19 139 0059.510 0110.430 0050.920 0000.001198
93/06/02 153 0060.710 0124.690 0063.980 0000.000953
etc.....
---------------------------------------------------------
Mean Span-Zero Difference:      62.965
Std. Dev. Span-Zero Difference: 6.001
---------------------------------------------------------

Mean of the slopes:      0.000978
Std. Dev. of the slopes: 0.000097
Number of samples:        42
Degrees of freedom:       41
T value:                  2.021
Uncertainty: 0.2002  (20.0217%)
```

Figure 4-10. Example Uncertainty Analysis.

4.4.3 Review and Manual Validation of QA File Entries

The data coordinator reviews the preliminary QA calibration plots to identify invalid zero and span calibrations caused by incorrect nephelometer operation. The NGN_QA software generates plots showing the following:

- Zero calibrations that pass all software validation tests [**.**]
- Span calibrations coded as valid [**s**]
- Zero calibrations that fail at least one software validation test [**m**, **r**, >, <] (see below)
- Manually invalidated zero or span calibrations [**I**]
- Ambient temperature and relative humidity [**.**]

Zero calibrations are identified by the NGN_QA software as invalid (code r, m, >, <) for the following reasons:

• Mean Test (**m**)	In a given window of time (usually 30 days), the zero calibration exceeds the mean of all valid zeros in the window by a defined number of counts (usually 50).
• Linear Regression (**r**)	In a given window of time (usually 30 days) the zero calibration exceeds the linear b_{ext} fit value through the valid zeros in the Test window by a defined number of counts (usually 50).
• Absolute Minimum (<) or Maximum (>)	The zero calibration raw counts are less than the defined absolute minimum (usually 0) or greater than the defined absolute maximum (usually 500).

The window size, mean threshold, linear regression threshold, minimum, and maximum are defined in each QA file as is detailed in Figure 4-4.

Invalid calibrations *not identified by the software* must be invalidated manually by the data coordinator. The NGN_SEAS software or any ASCII text editor can be used to edit the QA files. The following codes are used in the QA calibration file:

1	:	Valid serial zero or span
A	:	Valid analog zero or span
I:	:	Invalid zero or span

Any code other than 1 is considered invalid by the NGN_SEAS software during Level-0 and Level-1 data reduction. Analog calibrations are recorded in the QA calibration files for backup purposes only - they are not used for data reduction. If serial data logging fails, analog calibrations can be coded with a 1 and used in place of serial data.

4.4.4 Generation of Final QA Calibration Plots and Uncertainty Estimates

The data coordinator generates final QA calibration plots after validating the zero and span calibrations based on the preliminary plots. Any invalid calibrations shown on the final plots as valid must be edited manually as described above. Uncertainty estimates generated during QA calibration plot review are entered manually in the QA database files by the data coordinator. The uncertainty estimates appear in the Level-1 data file for reference.

4.5 SEASONAL LEVEL-0 VALIDATION OF NEPHELOMETER AND METEOROLOGICAL DATA

Level-0 validation of nephelometer and meteorological data is performed seasonally and serves as an intermediate data reduction step. Level-0 data validation includes:

- Review of Level-A data
- Updating the NPROCESS.CON constants file
- Level-0 validation processing procedures

4.5.1 Review of Level-A Data

The data coordinator and project manager further review the Level-A nephelometer data and plots to identify periods of invalid nephelometer data caused by the following:

- Burned out lamp
- Power failures
- Water contamination
- Other problems

Level-A meteorological data are also reviewed to identify invalid periods caused by sensor failures.

4.5.2 Updating the NPROCESS.CON Constants File

The nephelometer data validation constants file (NPROCESS.CON) contains the following information:

Level-0 Validation Constants
Raw nephelometer underrange and overrange
Raw nephelometer rate-of-change
Ambient temperature underrange and overrange
Relative humidity underrange and overrange

Level-1 Validation Constants
Nephelometer raw std. dev. / mean filter
Nephelometer b_{scat} rate-of-change filter
Nephelometer b_{scat} RH filter
Nephelometer b_{scat} maximum filter

The NPROCESS.CON file must be updated as described in the following section with the correct data validation constants before Level-0 and Level-1 data validation can proceed. Figure 4-11 is an example nephelometer constants (NPROCESS.CON) file.

4.5.3 Level-0 Validation Processing Procedures

Level-0 validated nephelometer data are generated from Level-A data by the NGN_SEAS software using the following validation criteria:

- Nephelometer data with a Level-A nephelometer status code not equal to 1 are invalid at Level-0.
- Meteorological data with parameter values of -99 are invalid at Level-0.
- Nephelometer and meteorological data identified as invalid in the site-specific QA database files are considered invalid at Level-0.
- Out of range data and data whose rate of change between 5-minute values exceeds the specified criteria specified in the nephelometer constants (NPROCESS.CON) file is invalid at Level-0. Table 4-1 lists the range and rate-of-change criteria for IMPROVE nephelometer and meteorological data.

Table 4-1

Nephelometer and Meteorological Level-0 Validation Range Criteria

Parameter	Underrange	Overrange	Rate of Change
Nephelometer Raw Reading (counts)	0	9999	200
Ambient Temperature (°C)	-50	70	10
Relative Humidity (%)	0	100	25
Nephelometer Chamber Temperature (°C)	-50	50	10

Nephelometer data can be of any type (serial, analog, or DCP) to be valid at Level-0 validation. The Level-0 data file format and validity code summary is shown in Figure 4-12.

The following are the Level-0 data validation procedures:

EXECUTE NGN_SEAS SOFTWARE	Execute the NGN_SEAS software from the Windows Program Manager. The NGN_SEAS display will appear as shown in Figure 4-13.

NPROCESS.CON
Optec NGN-2 Nephelometer Data Processing Constants File
Last Updated: 4/22/94 (TRPA sites)

Last Update by: Scott

Site	Min raw (counts)	Max raw (counts)	Delta raw (counts)	SD/MEAN b*scat* (%)	Delta b*scat* (1/km)	Max b*scat* (1/km)	RH b*scat* (%)	AT (C) Range Limits Min	Max	Delta	RH (%) Range Limits Min	Max	Delta	CT (C) Range Limits Min	Max	Delta
ACAD,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
BOWA,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
CORG,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-30,	70,	5,	1,	105,	5,	-50,	50,	5
DOSO,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
EBFO,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
GRSM,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
JARB,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
LOPE,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
LYBR,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
MACA,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
MORA,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
MOZI,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-30,	50,	5,	1,	105,	5,	-50,	50,	5
OKEF,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
SNPA,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-30,	50,	5,	1,	105,	5,	-50,	50,	5
THSI,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
UPBU,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
ARE,	0,	5000.0,	200,	10,	0.05,	5.0,	95,	-50,	50,	10,	1,	105,	25,	-99,	-99,	-99
CTH,	0,	5000.0,	200,	10,	0.05,	5.0,	95,	-50,	50,	10,	1,	105,	25,	-99,	-99,	-99
QAK,	0,	5000.0,	200,	10,	0.05,	5.0,	95,	-50,	50,	10,	1,	105,	25,	-99,	-99,	-99
SIK,	0,	5000.0,	200,	10,	0.05,	5.0,	95,	-50,	50,	10,	1,	105,	25,	-99,	-99,	-99
AFTC,	0,	9999.0,	100,	10,	0.05,	5.0,	-99,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
DALA,	0,	9999.0,	100,	10,	0.05,	5.0,	95,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
LTBV,	-500,	9999.0,	300,	25,	0.10,	5.0,	-99,	-30,	40,	5,	1,	105,	5,	-30,	40,	5
BLIS,	-500,	9999.0,	300,	25,	0.10,	5.0,	-99,	-30,	40,	5,	1,	105,	5,	-30,	40,	5
T13T,	0,	9999.0,	100,	10,	0.05,	5.0,	-99,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
T24T,	0,	9999.0,	100,	10,	0.05,	5.0,	-99,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
T38T,	0,	9999.0,	100,	10,	0.05,	5.0,	-99,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
TBEL,	-500,	9999.0,	100,	50,	0.05,	5.0,	-99,	-50,	50,	5,	1,	105,	5,	-50,	50,	5
RAYR,	-500,	9999.0,	100,	10,	0.05,	5.0,	-99,	-50,	50,	5,	1,	105,	5,	-50,	50,	5

Figure 4-11. Nephelometer Constants (NPROCESS.CON) File.

```
NGN_PULL  V1.11:10/07/93  12-02-1993  06:11:47------------------
LEVEL-0: NGN_SEAS 1.0A 12/03/93 12-14-1993 16:56:34-------------
----------------------------------------------------------------
----------------------------------------------------------------
----------------------------------------------------------------
----------------------------------------------------------------
---------------------------------------------------------------
----------------------------------------------------------------
----------------------------------------------------------------
----------------------------------------------------------------
ACAD 930701 182 0000   85.00  1111   0.00 X1  13.30 11  80.70 11
ACAD 930701 182 0100   80.00  1111   0.00 X1  13.10 11  81.80 11
ACAD 930701 182 0200   70.00  1111   0.00 X1  13.30 11  81.00 11

                 Column Number
         1         2         3         4         5         6
1234567890123456789012345678901234567890123456789012345678901234
```

Columns	Description
1-3	Site Abbreviation
6-7	Year
8-9	Month
10-11	Day
13-15	Julian Date
17-18	Hour
19-20	Minute
21-28	Raw Nephelometer Scattering Data (Counts)
31-34	Level-0 Nephelometer Validity Codes:
30	Power (Space = No Power Failure)
31	Nephelometer Status Code from Level-A (1-9)
32	Data Type (0 = Serial 1 = Analog 2 = DCP)
33	Validity Code from QA Database (1 = Valid, Any other = Invalid)
34	Level-0 Range Check Code (1 = Valid, Any other = Invalid)
35-41	Chamber Temperature (°C)
43-44	Chamber Temperature Validity Codes:
43	Validity Code from QA Database (1 = Valid, Any other = Invalid)
44	Level-0 Range Check Code (1 = Valid, Any other = Invalid))
45-51	Ambient Temperature (°C)
53-54	Ambient Temperature Validity Codes:
53	Validity Code from QA Database (1 = Valid, Any other = Invalid)
54	Level-0 Range Check Code (1 = Valid, Any other = Invalid))
55-61	Relative Humidity (%)
63-64	Relative Humidity Validity Codes:
63	Validity Code from QA Database (1 = Valid, Any other = Invalid)
64	Level-0 Range Check Code (1 = Valid, Any other = Invalid)

Note: The first ten lines are for data reduction information.

Figure 4-12. Level-0 Validated Nephelometer Data File Format.

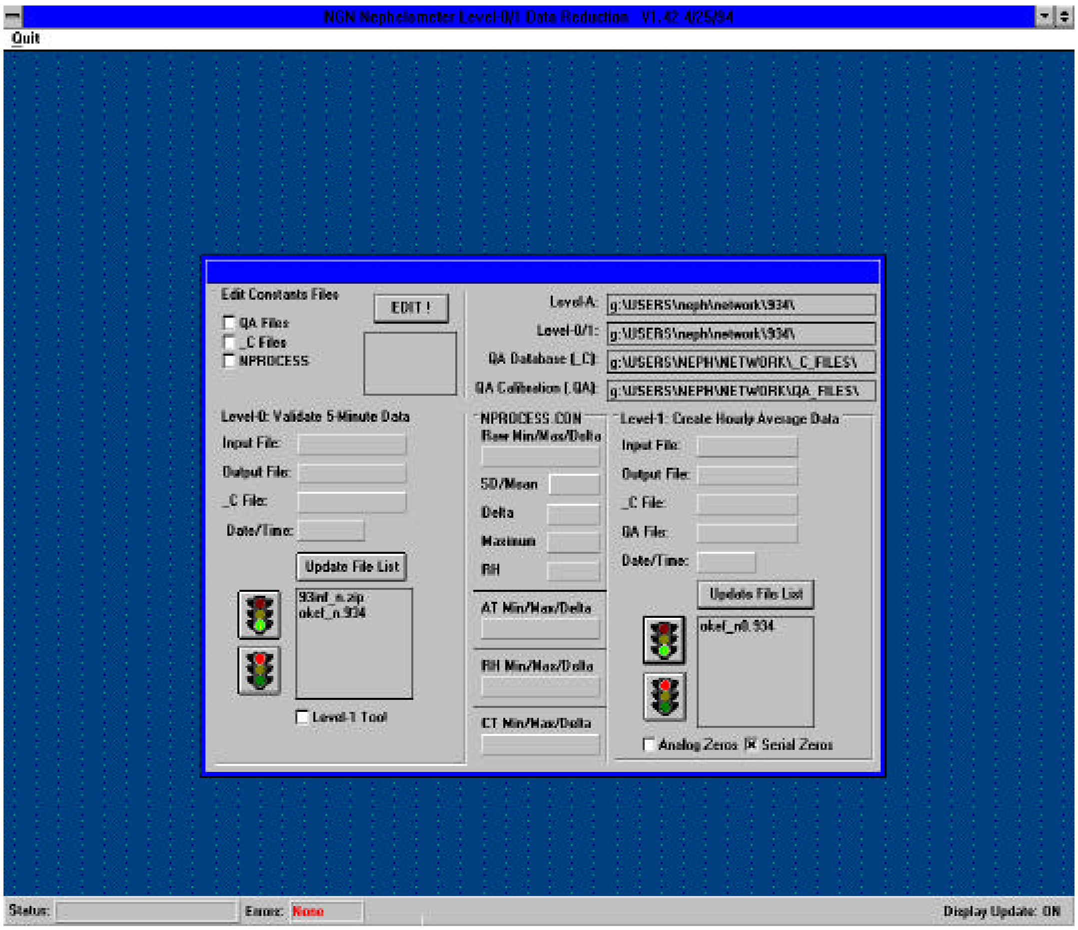

Figure 4-13. NGN_SEAS Software Display.

SET DATA DIRECTORIES

The directories for all files used by NGN_SEAS are shown on the NGN_SEAS display. Set the Level-A directory to the location where the Level-A data files exist by clicking the Level-A directory box. A dialog box will appear which allows the user to change the directory. Set the correct directory for the Level-0/1, QA database, and QA calibration code files the same way.

CHECK QA DATABASE CODE (XXXX_C) FILES

Verify that the QA database code (XXXX_C) files have been updated correctly as follows:

- Click the **_C Files** box in the **Edit Constants Files** frame.
- Highlight the file to edit in the **File to Edit** box.
- Click the **EDIT!** button to load the file into the Windows Notepad editor.
- Verify that the file is correct. Save any changes and exit Notepad.
- Check all the files that will be required for Level-0 validation.

CHECK QA CALIBRATION (XXX_N.QA) FILES

Verify that the QA calibration (XXX_N.QA) files have been updated correctly as follows:

- Click the **QA Files** box in the **Edit Constants Files** frame.
- Highlight the file to edit in the **File to Edit** box.
- Click the **EDIT!** button to load the file into the Windows Notepad editor.

  The following validity codes are used to manually edit the QA calibration files:

  1: Valid Serial Calibration
  I: Invalid
  A: Valid Analog Calibration
- Verify that the file is correct. Save any changes and exit Notepad.
- Check all the files that will be required for Level-1 validation.

CHECK CONSTANTS (NPROCESS.CON) FILE

Verify the Level-0 and Level-1 data validation constants in the are correct as follows:

- Click the **NPROCESS.CON** box in the **Edit Constants Files** frame.
- Highlight the file to edit in the **File to Edit** box.

- Click the **EDIT!** button to load the file into the Windows Notepad editor.

  Edit the constants as required in the NPROCESS.CON file.

- Verify that the file is correct. Save any changes and exit Notepad.

- Check all the files that will be required for Level-1 validation.

START LEVEL-0 VALIDATION

Start the Level-0 validation processing as follows:

- Click the **Update** button to update the list of available Level-A validated files to process.

- Highlight the Level-A validated file(s) to process.

- Click the **GREEN LIGHT** icon to start the Level-0 validation process.

- Click the **RED LIGHT** icon to stop any processing in progress.

- Each highlighted level-A file will be processed in order. The Level-0 validated data will be output to the file shown in the **Output File** box.

- The **Status** box will show the current processing status. When all the highlighted files have been processed the status box will show **DONE**.

The input, output, QA database, and QA calibration file names being used for processing are updated on the NGN_SEAS display. The file naming conventions are detailed in Table 4-2.

CHECK ERRORS

Any errors encountered by NGN_SEAS during data validation are recorded in the file NGN_SEAS.ERR. The number of errors will be displayed at the bottom of the NGN_SEAS display.

To check the errors click on the **Errors** at the bottom of the display. The Notepad program will be invoked to view the error file. Correct any errors by updating the following files:

- QA database files

- QA calibration files

- Nephelometer constants (NPROCESS.CON) file

Table 4-2

Nephelometer and Meteorological Data File Naming Conventions

Validation Level	File Naming Convention	Example
Daily Raw	SSSSYYDX.JJJ, where SSSS = site code YY = year X = A,1,2....9 JJJ = Julian date	ACAD93DA.321 Acadia daily raw file for Julian date 321 of 1993.
Seasonal Site-Specific Level-A	SSSS_N.YYN, where SSSS = site code YY = year N = season	ACAD_N.933 Acadia Level-A Summer season 1993
Seasonal Site-Specific Level-0	SSSS_N0.YYN, where SSSS = site code YY = year N = season	ACAD_N0.933 Acadia Level-0 Summer season 1993
Seasonal Site-Specific Level-1	SSSS_N1P.YYN, where SSSS = site code P = averaging period (hours) YY = year N = season	ACAD_N11.933 Acadia Level-1 hourly average Summer season 1993

4.6 SEASONAL LEVEL-1 VALIDATION OF NEPHELOMETER AND METEOROLOGICAL DATA

Level-1 validation of nephelometer and meteorological data is performed seasonally following Level-0 validation. Level-1 validation of nephelometer and meteorological data is handled by the NGN_SEAS software. NGN_SEAS handles the following tasks:

- Computation of hourly averages from Level-0 data
- Automatic validation of QA calibration file entries
- Conversion of hourly average data to engineering units
- Overrange/underrange checks
- Identification of nephelometer b_{scat} data affected by meteorological interference
- Estimation of precision

Level-1 is typically the final validation level for IMPROVE nephelometer data. The following subsections detail the Level-1 validation of nephelometer and meteorological data in the order NGN_SEAS performs the above listed operations:

- Level-1 validation processing procedures
- Level-1 seasonal summary plots
- Review of Level-1 seasonal summary plots

4.6.1 Computation of Hourly Averages from Level-0 Data

Level-1 hourly averages are computed from Level-0 validated data for nephelometer and meteorological parameters. The data in an hourly average period includes the data following the hour. For example, the hourly average for 11:00 includes data from 11:00 through 11:59.

4.6.2 Automatic Validation of QA Calibration File Entries

The zero calibration information in the QA calibration files is used to calculate a calibration line for each nephelometer data point. Validation of QA zeros is detailed in Section 4.4.

4.6.3 Conversion of Hourly Average Data to Engineering Units

- Meteorological data (ambient and chamber temperatures and relative humidity) are already in engineering units.
- The nephelometer scattering coefficient (b_{scat}) of total extinction (b_{ext}) is calculated by determining a calibration line for each raw nephelometer scattering data point as follows:

- The ***Zero*** is determined by interpolating (in time) between the valid clean air calibrations prior to, and following the data point.

- The ***Initial Span*** is determined from the initial calibration of the instrument upon installation.

  Initial Span = Initial Upscale Span Gas Calibration - Initial Clean Air Calibration

- The ***Rayleigh*** coefficient is the site-specific altitude-dependent scattering of particle-free air.

- The ***Designated Span*** is determined by the span gas used during the initial calibration, and the Rayleigh coefficient. The span gas SUVA (HFC-134a) (Dupont) has been shown to scatter 7.1 times that of particle-free (Rayleigh) air.

  Designated Span = 7.1 x ***Rayleigh***

- The slope and intercept of the calibration line are:

  Slope = (***Designated Span*** - ***Rayleigh***) / ***Initial Span***
  Intercept = ***Rayleigh*** - (***Slope*** x ***Zero***)

- Nephelometer data and calibrations are in unitless counts. If the units for the Rayleigh coefficient are km^{-1}, the units for b_{scat} will also be km^{-1}. Nephelometer scattering (b_{scat}) is calculated from the calibration line as follows:

  b_{scat} = (***Slope*** x Raw Nephelometer Value) + ***Intercept***

4.6.4 Level-1 Range Checks

The following additional validation checks are performed to complete the Level-1 validation process:

- Data invalid at Level-0 is invalid at Level-1
- Calculated b_{scat} data less than Rayleigh scattering is invalid
- Meteorological data is not validated beyond Level-0

The file format for Level-1 validated data is provided in Figure 4-14.

Figure 4-14. Level-1 Validated Nephelometer Data File Format.

```
NGN_PULL     V1.91:2/15/94     02-15-1994     14:12:39------------------------------------------------------------------------------------------------------------------------------------------------
LEVEL-0:  NGN_SEAS  1.3  3/2/94  03-02-1994  15:01:19----------------------------------------------------------------------------------------------------------------------------------------------
LEVEL-1:  NGN_SEAS  1.3  3/2/94  03-02-1994  17:43:10----------------------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

SITE YYMMDD  JD HHMM INS  BSCAT  PREC    VA  RAW-M   RAW-SD  #  N/A   SD/M  DEL   MAX     RH 0123456789MPM0T  YINTER   SLOPE     AT  AT-SD  #  AT-PR    CT  CT-SD  #   CT-PR    RH  RH-SD  #   RH-PR N/A
LOPE 931130 334 1900 014  0.057  0.000   XL  122.68  25.49  12 -99.0  10.0  0.10  5.00   -99 0C0000000000000 -0.0450 0.00083  -0.97  0.20  12   1.00   0.22   0.20 12   1.00  88.01   1.18 12   2.00XXXX
LOPE 931130 334 2000 014  0.080  0.000   V   151.25   8.71  12 -99.0  10.0  0.10  5.00   -99 0C0000000000000 -0.0457 0.00083  -1.47  0.11  12   1.00  -0.25   0.10 12   1.00  90.46   0.88 12   2.00XXXX
LOPE 931130 334 2100 014  0.087  0.000   V   160.71   8.58  12 -99.0  10.0  0.10  5.00   -99 0C0000000000000 -0.0465 0.00083  -1.78  0.28  12   1.00  -0.44   0.19 12   1.00  90.71   0.96 12   2.00XXXX
LOPE 931130 334 2200 014  0.072  0.000   XD  143.10  22.18  12 -99.0  10.0  0.10  5.00   -99 0C0000000000000 -0.0472 0.00083  -2.65  0.21  12   1.00  -1.16   0.19 12   1.00  92.16   0.32 12   2.00XXXX
LOPE 931130 334 2300 014  0.070  0.000   XD  142.32  21.74  12 -99.0  10.0  0.10  5.00   -99 0C0000000000000 -0.0479 0.00083  -3.17  0.15  12   1.00  -1.65   0.11 12   1.00  91.63   0.51 12   2.00XXXX


                                                                                                        Column Number

         1         2         3         4         5         6         7         8         9        10        11        12        13        14        15        16        17        18        19        20
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
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Column	Data
1-4	Site Abbreviation
6-7	Year
8-9	Month
10-11	Day
13-15	Julian Day
17-18	Hour
19-20	Minute
22-24	Nephelometer Serial Number
26-32	b_{scat} (km^{-1})
34-40	b_{scat} Estimated Precision (%/100)
42-43	b_{scat} Validity/Interference Code
45-51	Raw Nephelometer Hourly Average (Counts)
53-59	Standard Deviation of Raw Nephelometer Average (Counts)
61-62	Number of Data Points in Hourly Nephelometer Average
64-68	(Not Used)
70-74	Standard Deviation/Mean Interference Threshold
76-81	b_{scat} Rate of Change Interference Threshold
83-88	Maximum b_{scat} Interference Threshold
90-92	Relative Humidity Interference Threshold
94-108	Composite Nephelometer Code Summary
110-116	Y-intercept of Calibration Line Used to Calculate b_{scat}
118-124	Slope of Calibration Line Used to Calculate b_{scat}
126-131	Average Ambient Temperature (°C)
133-138	Standard Deviation of Hourly AT Average
140-141	Number of Data Points in Hourly AT Average
143-148	Estimated Precision of Ambient Temperature
150-155	Average Nephelometer Chamber Temperature (°C)
157-162	Standard Deviation of Hourly CT Average
164-165	Number of Data Points in Hourly CT Average
167-172	Estimated Precision of Chamber Temperature
174-179	Average Relative Humidity (%)
181-186	Standard Deviation of Hourly RH Average
188-189	Number of Data Points in Hourly RH Average
191-196	Estimated Precision of Relative Humidity
197-200	(Not Used)

b_{scat} Validity/Interference Code:

V = Valid
I = Invalid
< = b_{scat} less than Rayleigh scattering
XZ = Data point immediately preceded and followed by interference
X? = Interference of type ?

Type (?) of Interference	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
RH > max. threshold	x		x		x		x		x		x		x		x
b_{scat} > max. threshold	x	x			x	x			x	x			x	x	
St. Dev./Mean>threshold				x	x	x						x	x	x	x
b_{scat} rate of change > threshold								x	x	x	x	x	x	x	x

Composite Nephelometer Code Summary:

94-103	Nephelometer diagnostic code (internal use)
104	Number of missing data points
105	Number of power failure codes
106	Number of manual QA invalidation codes
107	Number of Level-0 invalidated data points
108	Number of times non-serial data were used

Note: The first 10 lines are for data reduction information.

4.6.5 Identification of Nephelometer b_{scat} Data Affected by Meteorological Interference

Nephelometer data is filtered to identify periods likely affected by meteorological interference. The following filter criteria (defined in the nephelometer constants file, NPROCESS.CON) are used to identify these periods:

- Rate of Change: If the rate of change between nephelometer hourly b_{scat} data exceeds the following threshold, the b_{scat} value is coded as filtered:

  Nephelometer b_{scat} rate-of-change threshold: 0.05 km^{-1}

- Maximum: If the nephelometer b_{scat} data exceeds the following threshold, the b_{scat} value is coded as filtered:

  Nephelometer b_{scat} maximum threshold: 5.0 km^{-1}

- Relative Humidity: If the relative humidity corresponding to the nephelometer b_{scat} value exceeds the following threshold, the b_{scat} value is coded as filtered:

  Nephelometer b_{scat} RH threshold: 95%

- σ/μ: If the standard deviation of the hourly raw nephelometer data divided by the mean of the hourly raw nephelometer data exceeds the following threshold, the value is coded as filtered:

  Raw nephelometer σ/μ threshold: 10%

Nephelometer data identified as affected by meteorological interference is still considered valid. An additional validity code is assigned to the hourly average data point in the Level-1 file as shown in Figure 4-14.

4.6.6 Estimation of Precision

The following methods are used to estimate the precision of Level-1 validated data.

- The precision of meteorological data are defined by the factory specified precision for the sensors. These precision are recorded in the site-specific QA database files. Typical precisions of meteorological sensors are detailed in Table 4-3.

Table 4-3

Typical Factory-Defined Precisions of Meteorological Sensors

Sensor	Precision
Rotronics Ambient Temperature	± 0.5 °C
Rotronics Relative Humidity	± 2 %
Optec NGN-2 Nephelometer Chamber Temperature	± 2 °C

- The estimated precision of nephelometer data for a given time period is based on calibrations performed during that time period. The precision estimates for are recorded in the site-specific QA database files and are automatically placed in the Level-1 data files. The relative error (uncertainty) in scattering due to drift of the slope of the calibration line is evaluated based on the instrument specific zero and span checks performed. The following statistical analysis was applied to calculate potential uncertainty:

$V(t)$	=	Normalized nephelometer reading at time t
$V_o(t)$	=	Normalized clean air reading at time t
$V_s(t)$	=	Normalized SUVA 134a reading at time t
$b_{scat,o}$	=	Scattering coefficient for clean air
$b_{scat,s}$	=	Scattering coefficient for SUVA 134a
V_o	=	average normalized clean air reading
V_f	=	average normalized SUVA 134a reading
$b_{scat}(t)$	=	theoretical scattering coefficient at time t
m	=	slope of the calibration line used to calculate the theoretical scattering coefficient $b_{scat}(t)$

$$m = \frac{(b_{scat,s} - b_{scat,o})}{(V_s(t) - V_o(t))}$$

Given a normalized nephelometer reading *V(t)*, the theoretical b_{scat} at time *t* is:

$$b_{scat}(t) = b_{scat,o} + m(V(t) - V_o(t))$$

assuming that $V_o(t)$ and $V(t)$ are known without error.

The slope of the calibration line is not constant as defined above, but changes (drifts) with time. Figure 4-15 illustrates the drift in the clean air and span values with time. Figure 4-16 illustrates how these drifting values cause the slope of the calibration line to drift.

The actual slope of the calibration line at time *t* is:

$$m(t) = (b_{scat,s} - b_{scat,o}) / (V_s(t) - V_o(t))$$

The actual b_{scat} (denoted b'_{scat}), given a nephelometer reading *V(t)*, is:

$$b'_{scat}(t) = b_{scat,o} + m(t)\ (V(t) - Vo(t))$$

The relative error between the theoretical b_{scat} and actual $b¢_{scat}$ is:

$$= ((m - m(t))\ (V(t) - V_o(t))) / (b_{scat,o} + m(V(t) - V_o(t)))$$

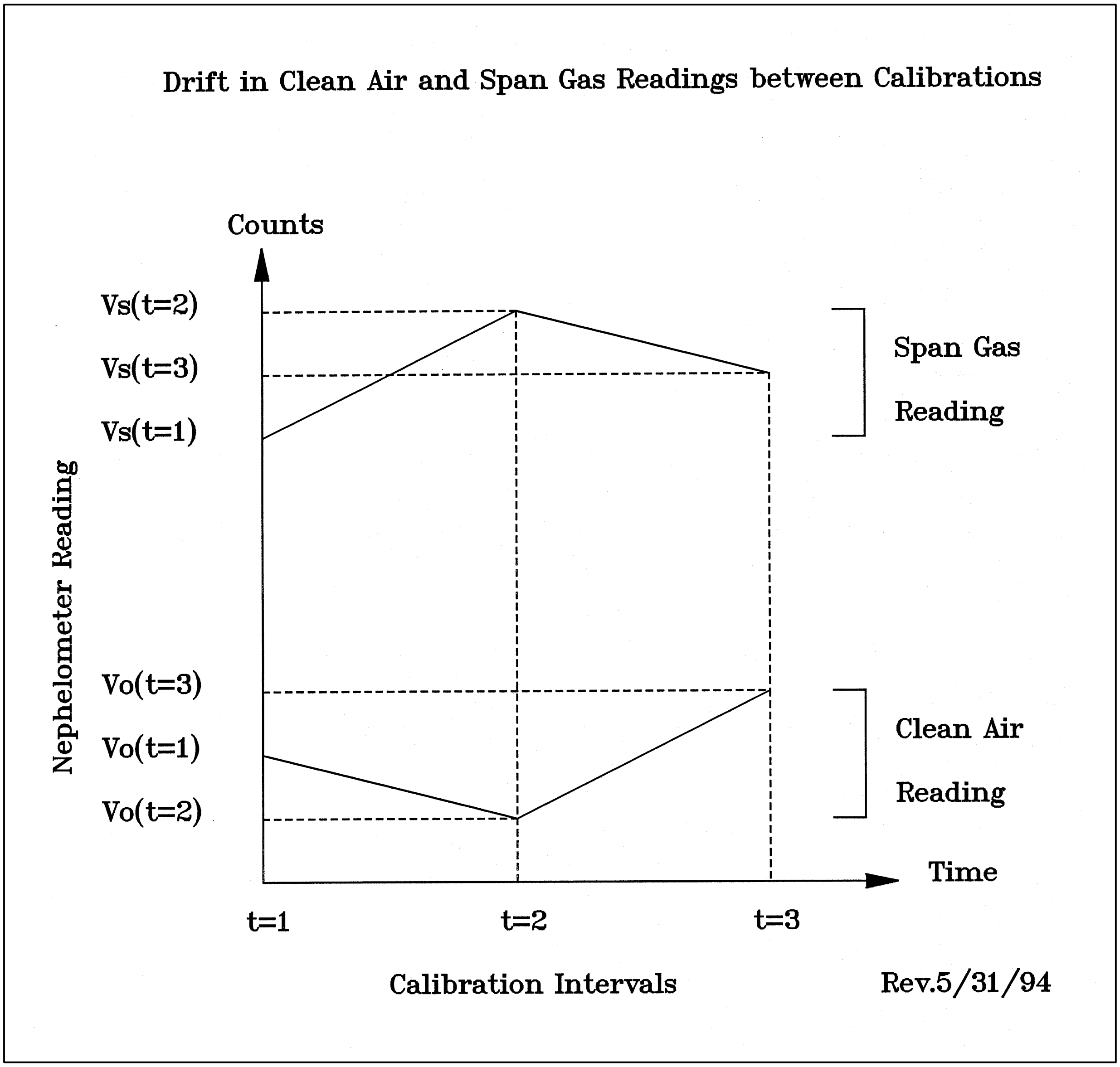


Figure 4-15. Drift in the Clean Air and SUVA 134a Values With Time.

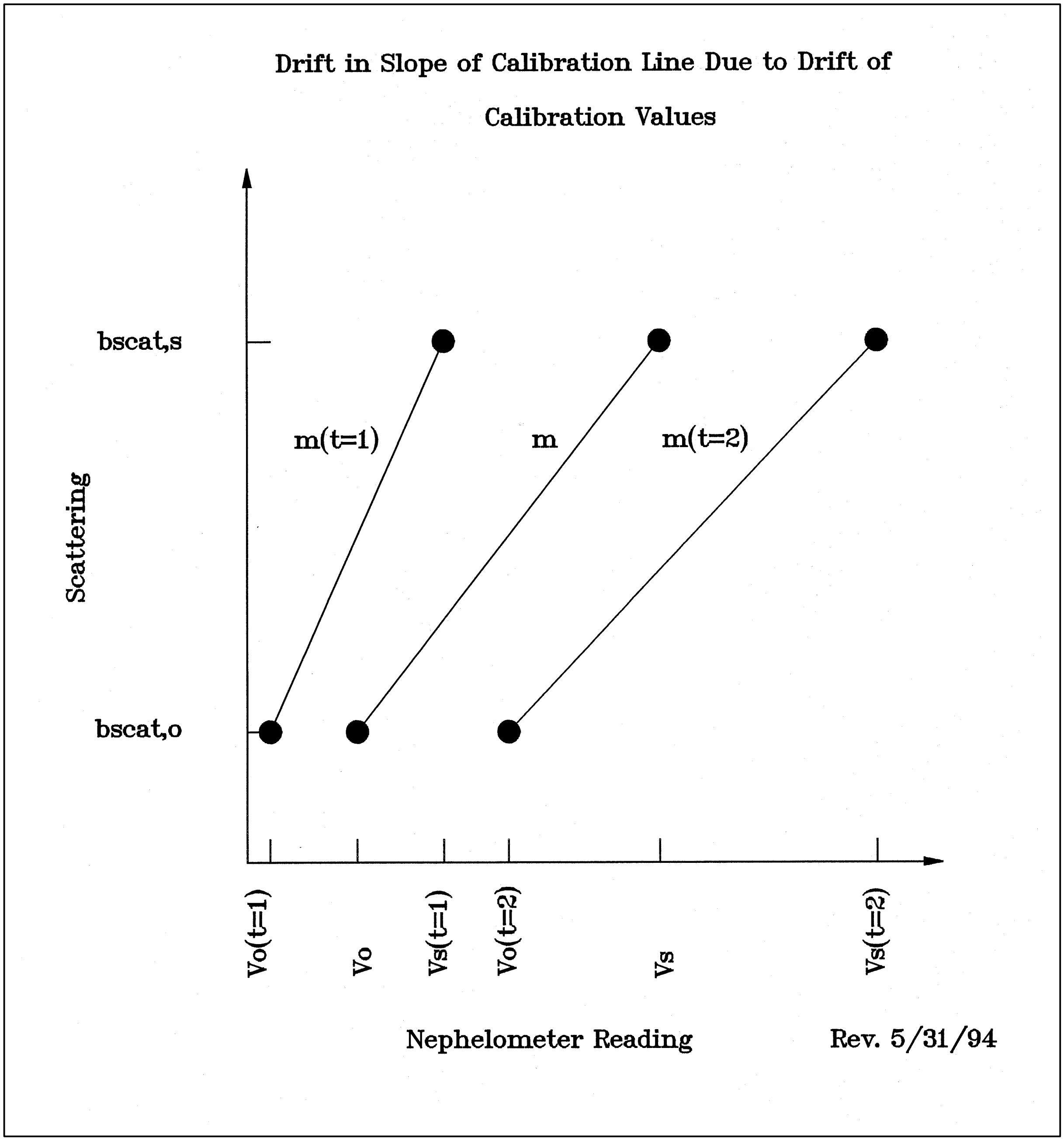


Figure 4-16. Drift in Slope of Calibration Line Due to Drift of Calibration Values.

$$relative \quad error = (b_{scat}(t) - b'_{scat}(t)) \;/\; b_{scat(t})$$

$$= (m - m(t)) \;/\; (b_{scat,o} \;/\; (V(t) - V_o(t)) \; m$$

$$= \left| (m - m(t)) \;/\; (b_{scat,o} \;/\; (V(t) - Vo(t)) + m) \right|$$

The magnitude of the relative error is:

$$\left| relative \quad error \right| = \left| (b_{scat}(t) - b'_{scat}(t)) \;/\; b_{scat}(t) \right|$$

The magnitude of the relative error is bounded by the slopes such that:

$$\left| relative \quad error \right| \leq \left| (m - m(t)) \;/\; m \right|$$

Assuming that the calculated slopes, *m(t)*, of the calibration lines are normally distributed about the average slope *m* with a standard deviation *s*, then for a probability (confidence level) of 95%:

$$\left| m - m(t) \right| \leq 2s$$

so that

$$\left| (b_{scat}(t) - b'_{scat}(t)) \;/\; b_{scat}(t) \right| \leq \left| 2s \;/\; m \right|$$

Assuming that *s* is estimated by s_m with k degrees of freedom, based on k+1 sample values of *m(t)*, and using the two-tailed *t* distribution, the relative error at a 95% confidence level (which for a two-tailed *t* distribution is read from the 97.5 column of the *t* table) is:

$$\left| relative \quad error \right| \leq t_{k,0.025} \times s_m \;/\; m$$

4.6.7 Level-1 Validation Processing Procedures

Level-1 validation of nephelometer data, detailed above, is handled by the NGN_SEAS software.

Level-1 nephelometer and meteorological data reduction, detailed above, is handled by the NGN_SEAS software. The procedures for validating data to Level-1 are as follows:

EXECUTE NGN_SEAS SOFTWARE	Execute the NGN_SEAS software from the Windows Program Manager. The NGN_SEAS display will appear as shown in Figure 4-13.

CHECK QA DATABASE (XXXX_C) FILES	Verify that the QA database files (XXXX_C) are correct as is described in the Level-0 validation section of this TI.
CHECK QA CALIBRATION (XXX_N.QA) FILES	The QA calibration files are nephelometer-specific files containing the automatic the automatic and manual clean air zero and span calibrations performed on the instrument. The clean air calibrations are used to calculate the calibration line for each nephelometer data point. Invalid calibrations must be coded as invalid in the QA calibration files as described in the Level-0 validation section of this TI.
CHECK NPROCESS FILE	The nephelometer constants (NPROCESS.CON) file contains the data validation constants used for Level-0 and Level-1 validation. Verify the constants in the file as described in the Level-0 validation section of this TI.
START LEVEL-1 VALIDATION	Start the Level-1 validation processing as follows: • Click the **Update** button to update the list of available Level-0 validated files. • Highlight the Level-0 validated file(s) to process. • Click the **GREEN LIGHT** icon to start the Level-1 validation process. • Click the **RED LIGHT** icon to stop any processing in progress. • Each highlighted Level-0 file will be processed in order. The Level-1 validated data will be output to the file shown in the **Output File** box. • The **Status** box will show the current processing status. When all the highlighted files have been processed the status box will show **DONE**.
CHECK ERRORS	Any errors encountered by NGN_SEAS during data validation are recorded in the file NGN_SEAS.ERR. The number of errors will be displayed at the bottom of the NGN_SEAS display. To check the errors click on the **Errors** at the bottom of the display. The Notepad program will be invoked to view the error file. Correct any errors by updating the following files: • QA database files • QA calibration files • Nephelometer constants file (NPROCESS.CON) After updating the listed files, start Level-0 and Level-1 validation again.

4.6.8 Level-1 Seasonal Summary Plots

Level-1 validated nephelometer and relative humidity data are summarized in seasonal summary plots. Figure 4-17 shows an example seasonal summary plot. The plots are described in detail below:

4-Hour Average Variation in Visual Air Quality (Filtered Data)
Timeline of 4-hour average scattering data filtered to remove data affected by meteorological interference. The data are plotted as b_{scat} (km^{-1}).

Relative Humidity
Timeline of hourly relative humidity. Note that periods of high scattering are often associated with periods of high relative humidity.

Frequency of Occurrence and Cumulative Frequency Summary
Frequency of occurrence distribution of hourly scattering data, both unfiltered and filtered for meteorological interference. The 10% to 90% values are plotted in 10% increments and are summarized in the table next to the plot. The 50% value represents the median of the valid hourly averages.

Visibility Metric
Visibility statistics for data filtered for meteorological interference, including:

- Mean of the cleanest 20% of valid data
- Mean of all valid data
- Mean of the dirtiest 20% of valid data

Nephelometer Data Recovery
Data collection statistics, including:

- Total number of hourly averages possible in the period
- Number of valid hourly averages including filtered and unfiltered data
- Number of valid hourly averages including filtered data only
- Filtered data as percent of unfiltered and filtered data

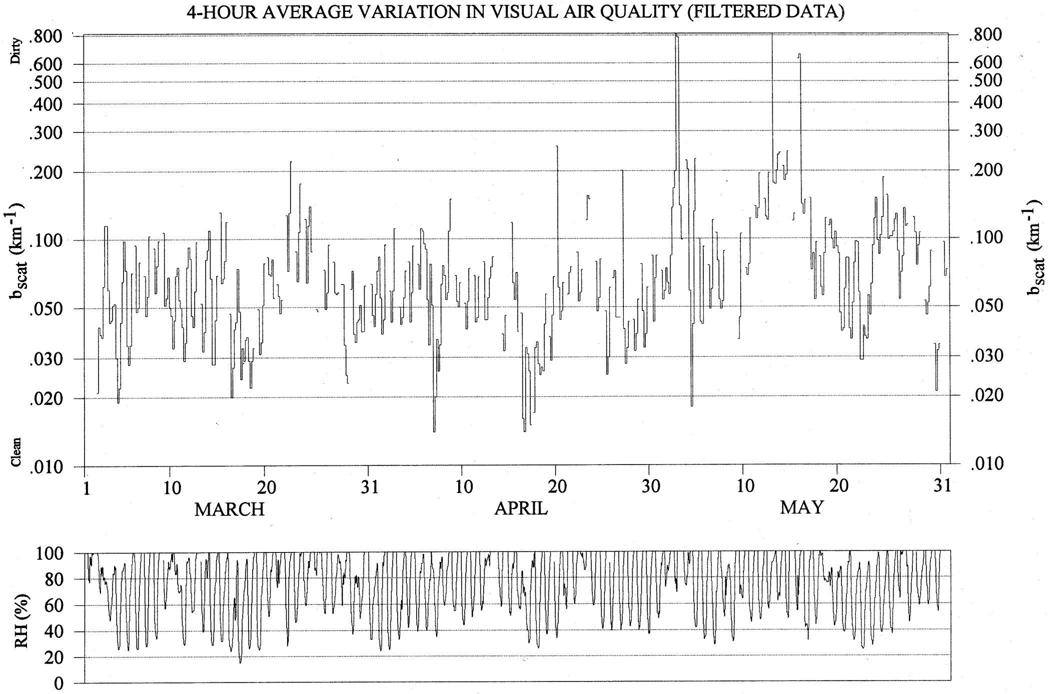
Seasonal summary plots are generated using the NGN_NSUM software. The following procedures describe the operation of the NGN_NSUM software:

EXECUTE NGN_NSUM SOFTWARE	Execute the NGN_NSUM software from the Windows Program Manager. The NGN_NSUM display will appear as shown in Figure 4-18.
EDIT THE SUBMIT FILE	The submit file defines the Level-1 validated data files and associated parameters used to generate the plots. Figure 4-19 details the format of the submit file. The following procedures are used to edit the submit file:

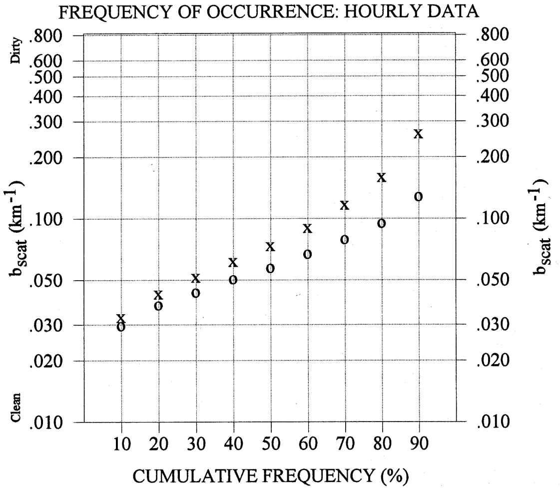
- Click on **File**. Click on **Edit Submit File**. The Windows Notepad program will be launched.
- Open an existing submit file or create a new one in Notepad.
- Save the submit file and exit Notepad.

OKEFENOKEE NATIONAL WILDLIFE REFUGE, GEORGIA
IMPROVE Nephelometer Data Summary
Spring Season: March 1, 1994 - May 31, 1994

4-HOUR AVERAGE VARIATION IN VISUAL AIR QUALITY (FILTERED DATA)



FREQUENCY OF OCCURRENCE: HOURLY DATA



CUMULATIVE FREQUENCY SUMMARY

%	Unfiltered Data [x] b_{scat}	Filtered Data [o] b_{scat}
10	0.033	0.030
20	0.043	0.038
30	0.052	0.044
40	0.062	0.051
50	0.074	0.058
60	0.091	0.068
70	0.118	0.080
80	0.161	0.096
90	0.264	0.130

VISIBILITY METRIC (FILTERED DATA)

	b_{scat}
Mean of cleanest 20%	0.029
Mean of all data	0.075
Mean of dirtiest 20%	0.162

NEPHELOMETER DATA RECOVERY	NUM	%
Total Possible Hourly Averages In The Time Period	2208	100
Valid Hourly Averages (Filtered and Unfiltered)	2108	95
Valid Hourly Averages (Filtered)	1461	66
Filtered Data Percent Of Filtered and Unfiltered Hourly Averages		69

N11:08/21/94 11:16 a P:08/24/94[-99] V1.44:8/18/94

Figure 4-17. Example Level-1 Seasonal Summary Plot.

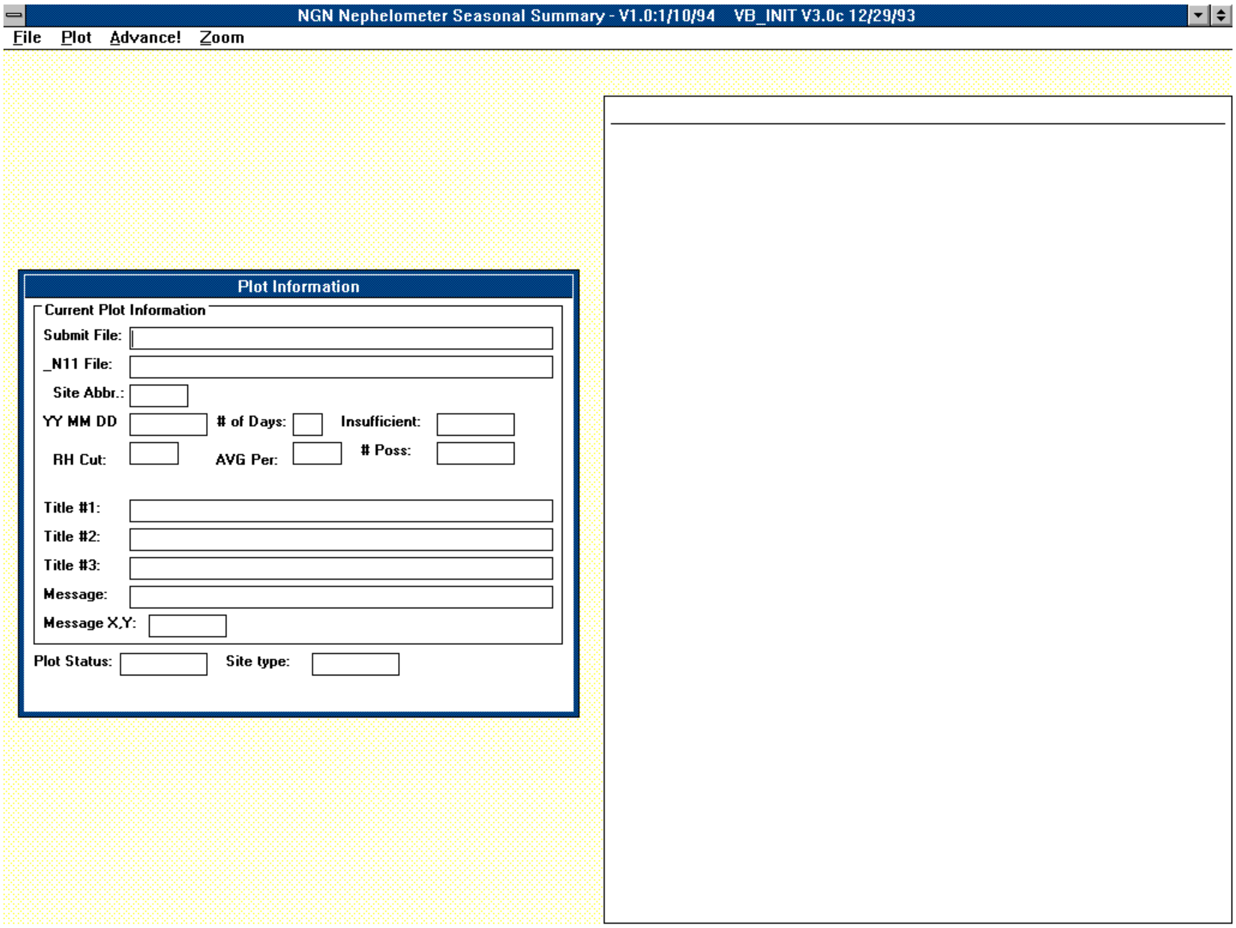


Figure 4-18. NGN_NSUM Software Display.

ACAD_N11.933	Level-1 validated file name
ACAD	Site abbreviation
93,7,1	Year, month, and day of start of plot
92	Number of days to read from file
0	Number possible hours, 0=ALL
1	Plot scale (0=WEST 1=EAST)
-99	RH filter threshold (%) (-99 for IMPROVE)
4	Averaging period for timeline plot (hours)
0	Draw timeline daily lines? (0=NO 1=YES)
ACADIA NATIONAL PARK, MAINE	Main title
IMPROVE Nephelometer Data Summary	Second title
July 1, 1993 - September 30, 1993	Third title
Lightning Surge 8/28/93	Timeline plot comment
3.5,1.5	Location of comment (" from upper left)
MORA_N11.933	Next site.....
MORA	
93,7,1	
92	
0	
1	
-99	
4	
0	
MOUNT RAINIER NATIONAL PARK, WASHINGTON	
IMPROVE Nephelometer Data Summary	
July 1, 1993 - September 30, 1993	
-99,-99	

Figure 4-19. NGN_NSUM Software Submit File Format.

GENERATE THE PLOTS

The plots defined in the submit file can be plotted to the screen or to any Windows-compatible printer attached to the system. The following procedures are used to generate the plots:

- Choose the submit file to use by clicking **File** and then **Choose Submit File**. Select the submit file to use from the file selection box.

- Generate the plots defined in the submit file by clicking **Plot** and then **Plot All Plots** (printer) or **Plot To Screen** (screen).

- The plots defined in the submit file will be sent to the printer selected by the user after clicking **Plot All Plots**.

4.6.9 Review of Level-1 Seasonal Summary Plots

Seasonal summary plots of Level-1 validated data are reviewed by the data coordinator and project manager to identify the following:

- Data reduction and validation errors
- Instrument operational problems
- Calibration problems

Problems identified in the Level-1 seasonal summary plot review are resolved by editing the QA database code and/or calibration files to identify additional data as valid or invalid and performing the Level-0 and Level-1 validation procedures again.

When the Level-1 seasonal summary plots have passed the review process, the raw through Level-1 validated data and associated QA files are archived as described in TI 4600-5000, Nephelometer Data Archiving.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**OPTICAL MONITORING DATA REPORTING**
TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4500**
DATE	**OCTOBER 1993**

AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
ORIGINATOR	Gloria S. Mercer	
PROJECT MANAGER	James H. Wagner	
PROGRAM MANAGER	David L. Dietrich	
QA MANAGER	Gloria S. Mercer	
OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
0.1	Revised nephelometer reporting units.	February 1996	

TABLE OF CONTENTS

1.0 PURPOSE AND APPLICABILITY

This standard operating procedures (SOP) is a guide to the written reporting of optical visibility monitoring data from sites operating according to IMPROVE Protocol. Optical monitoring sites include those equipped with an Optec LPV transmissometer and/or Optec NGN nephelometer.

IMPROVE Program goals include timely reporting of collected data in presentation formats that further the understanding of the visual resource and support effective management decisions. The program encompasses:

- Establishing baseline conditions and long-term trends of visual air quality in Class I wilderness areas, and monitoring progress toward the national visibility goals.
- Obtaining high quality visibility data that can be used in planning, permit review, and policy decision processes by using instrumentation capable of measuring quantities that can be directly related to those perceived by the human eye.
- Establishing a database that will assist in the scientific investigation of visibility and validation of computer models designed to predict visibility impairment.
- Determining the existing sources of visibility impairment, detecting new problems and developments early, and determining the sensitivity of individual vistas and Class I areas to varying concentrations of pollutants.

The program has partitioned visibility-related characteristics and measurements into three groups: optical, scene, and aerosol. This SOP pertains to the optical group and encompasses the following:

- Reporting the measurement of basic electro-optical properties of the atmosphere, independent of specific vista characteristics.
- Reporting data in various comprehensive graphics forms.
- Reporting optical extinction measurements made with transmissometers (represented in a variety of units including haziness in dv, extinction in km^{-1}, and standard visual range in km).
- Reporting optical scattering measurements made with nephelometers (represented as scattering in km^{-1}).

Data reports are prepared in a format that generally conforms to the *Guidelines for Preparing Reports for the NPS Air Quality Division* (AH Technical Services, 1987). The following technical instructions (TIs) provide detailed information regarding reporting data collected by optical instruments:

- TI 4500-5000 Nephelometer Data Reporting (IMPROVE Protocol)
- TI 4500-5100 Transmissometer Data Reporting (IMPROVE Protocol)

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Determine the COTR's (Contracting Officer's Technical Representative) project-specific reporting and distribution requirements).
- Review draft and final data reports for completeness and accuracy.
- Verify that completed reports are properly distributed.

2.2 DATA ANALYST

The data analyst shall:

- Prepare all final data plots for inclusion in the reports.
- Compile data statistics and compose text for draft reports.
- Coordinate with the secretary for report preparation.
- Review final reports for completeness and accuracy before distribution.

2.3 FIELD SPECIALIST

The field specialist shall provide current and accurate site specifications to the data analyst.

2.4 SECRETARY

The secretary shall:

- Word process draft and final reports.
- Coordinate with the data analyst for complete report information, format, and statistics.
- Prepare final, approved reports for photocopying and distribution.
- Distribute final reports in accordance with project-specific distribution requirements.

3.0 REQUIRED EQUIPMENT AND MATERIALS

All data reports are prepared on IBM-PC compatible systems. A word processing package capable of creating large documents with figures and tables is used (such as WordPerfect), with a letter-quality laserjet printer. Other materials include photocopy and binding machines (with required materials) or a photocopy and binding service.

4.0 METHODS

Data for each optical monitoring instrument type (nephelometer or transmissometer) are released in separate data reports. Data reports are prepared in a format that conforms to the *Guidelines for Preparing Reports for the NPS Air Quality Division* (AH Technical Services, 1987). Reporting consists of various text discussions and graphics presentations concerning the instrumentation and collected data. Specific contents of the seasonal and/or annual report are defined by the contracting agency COTR. This section includes four (4) subsections:

4.1 Seasonal Data Reporting
4.2 Annual Data Reporting
4.3 Other Reporting
4.4 Distribution

4.1 SEASONAL DATA REPORTING

Seasonal reporting is completed within three months after the end of a monitoring season. Standard meteorological monitoring seasons are defined as:

Winter	(December, January, and February)
Spring	(March, April, and May)
Summer	(June, July, and August)
Fall	(September, October, and November)

Optical data are presented in the following formats for each reporting season:

- Overview of monitoring program goals and objectives, and a description of the monitoring networks.
- Comprehensive discussion of data collection, reduction, and processing procedures.
- Brief overview of site configuration(s) and description of instrumentation.
- Map of all site locations and site abbreviations.
- Table of monitoring instrumentation history at each site.
- Table of site specifications and operating period for each site during the reporting season.
- Seasonal data summary plot for each site. The plots contain five data presentations: 1) a graph of the four-hour average variation in visual air quality, 2) a relative humidity graph, 3) a frequency of occurrence graph and table based on hourly data, 4) a visibility metric table, and 5) data recovery statistics.
- Detailed explanation of data presentations included in the summary plots.
- Discussion of events and circumstances influencing data recovery, specific for each site.

- Data recovery and cumulative frequency distribution table, including data recovery statistics and 10%, 50%, and 90% cumulative frequency values for each site. The table includes dv, b_{ext}, and SVR values for transmissometers and b_{scat} (filtered data and unfiltered data) values for nephelometers.

Refer to TI 4500-5000, *Nephelometer Data Reporting (IMPROVE Protocol)* and TI 4500-5100, *Transmissometer Data Reporting (IMPROVE Protocol)* for detailed discussions on each type of data presentation.

4.2 ANNUAL DATA REPORTING

Annual reporting is completed within three months after the end of the last season to be reported. Optical data are presented in the following formats for each annual reporting period:

- Overview of monitoring program goals and objectives, and a history of the program.

- Comprehensive discussion of data collection, reduction, and processing procedures.

- Brief overview of site configuration(s) and description of instrumentation.

- Map of all site locations and site abbreviations.

- Table of site specifications and operating period for each site and season during the annual reporting period.

- Seasonal data summary plots for each season and site. The plots contain five data presentations: 1) a graph of the four-hour average variation in visual air quality, 2) a relative humidity graph, 3) a frequency of occurrence graph and table based on hourly data, 4) a visibility metric table, and 5) data recovery statistics.

- Annual data summary plots for each site. The plots contain three data presentations: 1) a bar graph depicting the monthly median air quality values, 2) a monthly cumulative frequency summary table including data recovery statistics. The table displays dv and b_{ext} for transmissometers and b_{scat} (for filtered data and all data) values for nephelometers, and 3) an annual frequency of occurrence graph based on hourly data.

- Detailed explanation of data presentations included in the seasonal and annual data summary plots.

- Data recovery and cumulative frequency distribution tables for each season of the reporting period. The tables include data recovery statistics and 10%, 50%, and 90% cumulative frequency values for each site. The tables include dv, b_{ext}, and SVR values for transmissometers and b_{scat} (unfiltered data and filtered data) values for nephelometers.

Refer to TI 4500-5000, *Nephelometer Data Reporting (IMPROVE Protocol)* and TI 4500-5100, *Transmissometer Data Reporting (IMPROVE Protocol)* for detailed discussions on each type of data presentation.

4.3 OTHER REPORTING

Contracting agencies will periodically request additional data reports. Cases or events of special scientific, legal, or political importance to the NPS or other cooperating agencies may occur during the term of the project. New techniques, hardware, software, or other technical advances may also occur that will be applicable to the visibility monitoring program. Additional data reporting or analyses may be required to address these special circumstances and will be executed according to project-specific direction.

4.4 DISTRIBUTION

Reports are reviewed and approved by the project manager prior to preparation for distribution. When ready, ARS contacts the local project-specific COTR office for distribution requirements and provides the deliverable products as directed. The amount or type of deliverable product may vary with each report.

5.0 REFERENCES

AH Technical Services, 1987, Guidelines for Preparing Reports for the NPS Air Quality Division, September.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
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TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4500-5000**
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AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
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OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
0.1	Minor changes to responsibilities section.	February 1996	

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the procedures and methods for preparing written reports of Optec NGN-2 nephelometer data collected according to IMPROVE Protocol. This TI is referenced from SOP 4500, *Optical Monitoring Data Reporting*, and specifically describes:

- Reporting frequency and contents of seasonal nephelometer reports.
- Reporting contents of annual nephelometer reports.
- Report distribution requirements.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Determine the COTR's (Contracting Officer's Technical Representative) project-specific reporting and distribution requirements.
- Review draft and final data reports for completeness and accuracy.
- Verify that completed reports are properly distributed.

2.2 DATA ANALYST

The data analyst shall:

- Prepare all final data plots for inclusion in the reports.
- Compile data statistics and compose text for draft reports.
- Coordinate with the secretary for report preparation.
- Review final reports for completeness and accuracy before distribution.

2.3 FIELD SPECIALIST

The field specialist shall provide current and accurate site specifications to the data analyst.

2.4 SECRETARY

The secretary shall:

- Word process draft and final reports.
- Coordinate with the data analyst for complete report information, format, and statistics.

- Prepare final, approved reports for photocopying and distribution.
- Distribute final reports in accordance with project-specific distribution requirements.

3.0 REQUIRED EQUIPMENT AND MATERIALS

All data reports are prepared on IBM-PC compatible systems. A word processing package capable of creating large documents with figures and tables is used (such as WordPerfect), with a letter-quality laserjet printer. Other materials include photocopy and binding machines (with required materials) or a photocopy and binding service.

4.0 METHODS

Data reports are prepared in a format that generally conforms to the *Guidelines for Preparing Reports for the NPS Air Quality Division* (AH Technical Services, 1987). A separate data report is prepared for each instrument type; nephelometer data reports contain only nephelometer data. Reporting consists of various text discussions and graphics presentations concerning the instrumentation and collected data. Specific contents of the reports are defined by the contracting agency COTR. This section includes the following three (3) main subsections:

4.1 Seasonal Data Reporting
4.2 Annual Data Reporting
4.3 Report Distribution

4.1 SEASONAL DATA REPORTING

Seasonal nephelometer reporting is completed within three months after the end of a monitoring season. Standard meteorological monitoring seasons are defined as:

Winter	(December, January, and February)
Spring	(March, April, and May)
Summer	(June, July, and August)
Fall	(September, October, and November)

Seasonal reports contain the five (5) major sections listed below:

1.0 Introduction
2.0 Data Collection and Reduction
3.0 Nephelometer Data Summaries
4.0 References
A.0 Appendix A - Nephelometer Data Collection and Processing Procedures

The information and data presentation formats included in each section of the seasonal report are summarized in the following subsections.

4.1.1 <u>Introduction</u>

The introduction contains a conceptual overview of the purpose of the monitoring program and a description of the monitoring networks.

4.1.2 Data Collection and Reduction

Data collection and reduction is presented in two subsections, Site Configuration and Data Reduction.

4.1.2.1 Site Configuration

Nephelometer system components and basic system operation are briefly discussed in each seasonal report. Measurement principles and data collection specifications are also described. Detailed descriptions of system components and operation are presented in TI 4070-3001, *Site Documentation for Optec NGN-2 Nephelometer Systems*.

Figures and tables in this section include:

- Map of the United States depicting the location of all IMPROVE and IMPROVE Protocol monitoring network sites. An example map is presented as Figure 4-1.

- Monitoring History Summary Table - The table lists for each monitoring site the name, type of instrumentation, and period of operation for each instrument type (see Table 4-1).

- Site Specifications Summary Table - The table lists for each monitoring site the site name, abbreviation, latitude, longitude, and elevation of the nephelometer, the number of readings taken each day, and the operating period during the season (see Table 4-2).

4.1.2.2 Data Reduction

Each seasonal report contains a brief discussion of daily and seasonal data collection, reduction, and processing procedures. The discussion includes daily data review, file format, and daily and seasonal analytical processing and reduction procedures. Reduced data are presented as the scattering component of the atmospheric extinction coefficient (b_{scat}) in km^{-1}. More detailed discussions of collection and reduction procedures and assumptions (including discussion of levels of validation, calculation of uncertainties, and identification of meteorological and optical interferences) are presented in an appendix to each report (see Section 4.1.5). Refer to SOP 4300, *Collection of Optical Data (IMPROVE Protocol)*, and TI 4400-5010, *Nephelometer Data Reduction and Validation (IMPROVE Protocol)*, for a complete discussion of procedures.

4.1.3 Nephelometer Data Summaries

Data are presented in various forms in seasonal reports. Each mode of presentation is accompanied by an explanation of the presentation; the following two (2) subsections are included in each seasonal report and detail each data presentation.

4.1.3.1 Data Summary Description

A Seasonal Nephelometer Data Summary plot is prepared for each site that operated during the reporting season. An example Seasonal Nephelometer Data Summary is presented as Figure 4-2. The following is a detailed explanation of the contents of the data summaries and accompanies the summaries in each report. Nephelometer Data Summaries include the following five data presentations:

IMPROVE SITES

SITE ABRV.	SITE NAME
1. ACAC	ACADIA NP
2. BIBE	BIG BEND NP
3. BWCA	BOUNDARY WATERS CANOE AREA W
4. BRCN	BRYCE CANYON NP
5. BRID	BRIDGER W
6. CANY	CANYONLANDS NP
7. CARO	CAPE ROMAIN NWR
8. CHIR	CHIRICAHUA NM
9. CRLA	CRATER LAKE NP
10. DENA	DENALI NP
11. DOSO	DOLLY SODS W
12. EBFR	EDWIN B FORSYTHE NWR
13. GLAG	GLACIER NP
14. GRCT	GRAND CANYON NP
15. GRSM	GREAT SMOKY MOUNTAINS NP
16. JARB	JARBIDGE W
17. LYBW	LYE BROOK W
18. MACA	MAMMOTH CAVE NP
19. MEVE	MESA VERDE NP
20. MORA	MOUNT RAINIER NP
21. OKEF	OKEFENOKEE NWR
22. ROMM	ROCKY MOUNTAIN NP
23. SAGO	SAN GORGONIO W
24. SHES	SHENANDOAH NP
25. SHRO	SHINING ROCK W
26. SIPS	SIPSEY W
27. TONT	TONTO NM
28. UPBU	UPPER BUFFALO W
29. WEMI	WEMINUCHE W
30. YOSW	YOSEMITE NP

NON-IMPROVE SITES TO BE OPERATED ACCORDING TO IMPROVE PROTOCOL

SITE ABRV.	SITE NAME
1. BADL	BADLANDS NP
2. BAND	BANDELIER NM
3. GRBA	GREAT BASIN NP
4. GRSA	GREAT SAND DUNES NM
5. GUMO	GUADALUPE MOUNTAINS NP
6. HALE	HALEAKALA NP
7. HAWA	HAWAII VOLCANOES NP
8. LASS	LASSEN VOLCANIC NP
9. NACA	NATIONAL CAPITAL-CENTRAL
10. PEFO	PETRIFIED FOREST NP
11. PINN	PINNACLES NM
12. PORE	POINT REYES NS
13. REDW	REDWOOD NP
14. YELL	YELLOWSTONE NP

SITE NAME KEY

NP	National Park	NWR	National Wildlife Refuge
NM	National Monument	W	Wilderness
NS	National Seashore		

Figure 4-1. Example Visibility Network Location Map.

Table 4-1

Example Monitoring History Summary Table

NETWORK	SITE NAME	TELERADIOMETER				CAMERA				TRANSMISSOMETER		NEPHELOMETER	
		MANUAL		AUTO		MANUAL		AUTO					
		Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
IMPROVE	Acadia NP			10/79	02/86	01/80	10/84	04/85		11/87	06/93	06/93	
IMP Pro.	Badlands NP							08/87		01/88			
IMP Pro.	Bandelier NM	07/78	09/84			06/79	02/85	07/87		10/88			
IMPROVE	Big Bend NP	08/78	02/86			09/81	06/86	06/86		12/88			
IMPROVE	Boundary Waters Canoe Area W							10/85				05/93	
IMPROVE	Bridger W							09/86		07/88			
IMPROVE	Bryce Canyon NP	06/78	11/83	12/83	02/86	01/79	11/83	04/84					
IMPROVE	Canyonlands NP	09/78	02/86			07/82	01/87	01/87		12/86			
IMPROVE	Cape Romain NWR												
IMPROVE	Chiricahua NM	06/81	02/86			06/81	06/86	06/86		02/89			
IMPROVE	Crater Lake NP	07/82	09/82			08/82	09/82	06/85		09/88	09/91		
IMPROVE	Denali NP							06/88					
IMPROVE	Dolly Sods W							09/85				05/93	
IMPROVE	Edwin B. Forsythe NWR							05/92				04/93	04/94
IMPROVE	Glacier NP	06/83	05/85	06/85	11/85	07/82	06/85	06/85		02/88			
IMPROVE	Grand Canyon NP (South Rim)	07/78	10/83	12/83	02/86	10/79	11/83	11/83		12/86			
IMPROVE	Grand Canyon NP (In-Canyon)									12/89			
IMP Pro.	Great Basin NP	06/82	02/86			06/82	06/86	06/86		08/92			
IMP Pro.	Great Sand Dunes NM							07/87					
IMPROVE	Great Smoky Mountains NP			12/83	02/85			01/84				03/90	
IMP Pro.	Guadalupe Mountains NP			02/82	02/86	06/83	05/84	06/84		11/88			
IMP Pro.	Haleakala NM							07/87					
IMP Pro.	Hawaii Volcanoes NP							10/86					
IMPROVE	Jarbidge W							09/86				04/93	
IMP Pro.	Lassen Volcanic NP	07/82	11/83			08/82	10/83	06/87					
IMPROVE	Lye Brook W							05/87				08/93	04/94
IMPROVE	Mammoth Cave NP							03/92				03/93	
IMPROVE	Mesa Verde NP	07/78	02/86			09/79	06/86	06/86		09/88	06/93		
IMPROVE	Mount Rainier NP							06/85				06/90	
IMP Pro.	National Capital-Central							12/88					
IMPROVE	Okefenokee NWR							04/92	11/92			02/93	
IMP Pro.	Petrified Forest NP							07/86		04/87			
IMP Pro.	Pinnacles NM							08/86		03/88	06/93		
IMP Pro.	Point Reyes NS							06/87					
IMP Pro.	Redwood NP							06/87					
IMPROVE	Rocky Mountain NP	06/80	05/85			07/85	09/85	07/85		11/87			
IMPROVE	San Gorgonio W							08/86		04/88			
IMPROVE	Shenandoah NP	05/80	10/85			05/80	10/86	10/86		12/88			
IMPROVE	Shining Rock W												
IMPROVE	Sipsey W							11/88					
IMPROVE	Tonto NM							04/89		04/89	09/91		
IMPROVE	Upper Buffalo W							11/88				02/93	
IMPROVE	Weminuche W							08/86	08/93				
IMP Pro.	Yellowstone NP	06/81	06/82			09/81	06/82	09/86		07/89	06/93		
IMPROVE	Yosemite NP	09/82	07/83	01/84	10/85	09/82	09/83	09/84		08/88			

NETWORK KEY

IMPROVE - IMPROVE site
IMP Pro. - Non-IMPROVE site to be operated according to IMPROVE Protocol

SITE NAME KEY

NP - National Park
NM - National Monument
NS - National Seashore
NWR - National Wildlife Refuge
W - Wilderness

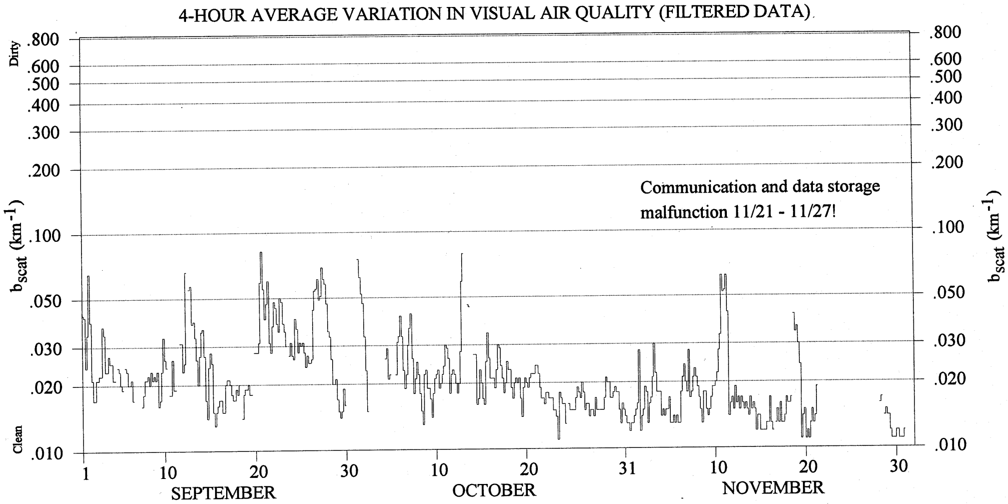
Table 4-2

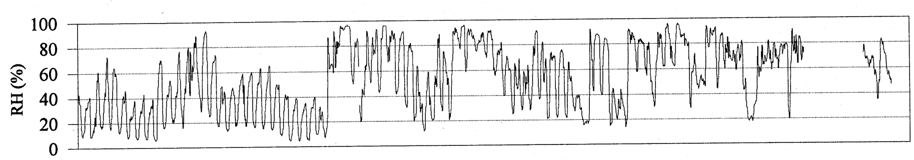
Example Nephelometer Site Specifications Summary Table

SITE NAME	SITE ABRV	INSTRUMENT LOCATION			OBS. PER DAY	OPERATING PERIOD DURING FALL 1994
		LAT (°N)	LONG (°W)	ELEV (M)		
ACADIA NATIONAL PARK	ACAD	44°22'27"	68°15'39"	122	288	09/01/94 - 11/30/94
BOUNDARY WATERS CANOE AREA WILDERNESS	BOWA	47°56'42"	91°29'47"	524	288	11/01/94 - 11/30/94
DOLLY SODS WILDERNESS	DOSO	39°06'17"	79°25'33"	1175	288	10/14/94 - 11/30/94
GREAT SMOKY MOUNTAINS NATIONAL PARK	GRSM	35°37'56"	83°56'32"	808	288	09/01/94 - 11/30/94
JARBIDGE WILDERNESS	JARB	41°53'33"	115°25'31"	1856	288	09/01/94 - 11/30/94
MAMMOTH CAVE NATIONAL PARK	MACA	37°13'04"	86°04'25"	225	288	09/01/94 - 11/30/94
MOUNT RAINIER NATIONAL PARK	MORA	46°45'28"	122°07'17"	420	288	09/01/94 - 11/30/94
OKEFENOKEE NATIONAL WILDLIFE REFUGE	OKEF	39°44'19"	82°07'00"	15	288	09/14/94 - 11/30/94
UPPER BUFFALO WILDERNESS	UPBU	35°49'32"	93°12'51"	696	288	09/01/94 - 11/30/94

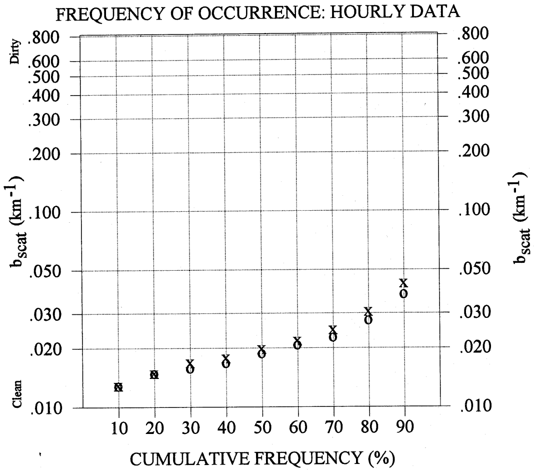
JARBIDGE WILDERNESS, NEVADA
IMPROVE Nephelometer Data Summary
Fall Season: September 1, 1994 - November 30, 1994

4-HOUR AVERAGE VARIATION IN VISUAL AIR QUALITY (FILTERED DATA)





FREQUENCY OF OCCURRENCE: HOURLY DATA



CUMULATIVE FREQUENCY SUMMARY

%	Unfiltered Data [x] b_{scat}	Filtered Data [o] b_{scat}
10	0.013	0.013
20	0.015	0.015
30	0.017	0.016
40	0.018	0.017
50	0.020	0.019
60	0.022	0.021
70	0.025	0.023
80	0.031	0.028
90	0.043	0.038

VISIBILITY METRIC (FILTERED DATA)

	b_{scat}
Mean of cleanest 20%	0.013
Mean of all data	0.023
Mean of dirtiest 20%	0.042

NEPHELOMETER DATA RECOVERY	NUM	%
Total Possible Hourly Averages In The Time Period	2184	100
Valid Hourly Averages (Filtered and Unfiltered)	1920	88
Valid Hourly Averages (Filtered)	1665	76
Filtered Data Percent Of Filtered and Unfiltered Hourly Averages		87

N11:02/08/95 11:43 a P:03/23/95[-99] V3.0:12/14/94

Figure 4-2. Example Seasonal Nephelometer Data Summary.

- **4-Hour Average Variation in Visual Air Quality (Filtered Data)** - Plot of four-hour averaged b_{scat} values (without interference-influenced observations) for each day of the reporting season. Gaps in the plot indicate that data were missing, interference-influenced, or failed validation procedures.

- **Relative Humidity** - Timeline of hourly average relative humidity measurements. This allows for a comparison of the effect of increasing relative humidity on measured b_{scat}.

- **Frequency of Occurrence: Hourly Data** - This plot is a frequency distribution of hourly average b_{scat} values, both unfiltered and filtered for meteorological interference. The 10% to 90% values are plotted in 10% increments and are summarized in the table to the right of the plot.

For b_{scat}, the 10%, 50%, and 90% values can be interpreted as:

Value	Interpretation
10%	10% of the time the b_{scat} was less than or equal to the 10% value;
50%	Median value; 50% of the b_{scat} observations are less than the 50% value and 50% of the observations are greater than the 50% value; and
90%	90% of the time the b_{scat} was less than or equal to the 90% value (10% of the time it was greater than or equal to the 90% value).

- **Visibility Metric (Filtered Data)** - This table presents mean values of filtered b_{scat} data affected by meteorological interference. The best, worst, and average conditions using the arithmetic means of the 20th percentile least impaired visibility, the 20th percentile most impaired visibility, and for all data for the season are presented.

- **Data Recovery Statistics**

Total Possible Hourly Averages in the Time Period - The total possible category is calculated by subtracting the number of hourly averages included in periods when the instrument was removed due to conditions unrelated to system performance (installation, construction, site relocation, etc.) from the theoretical maximum number of hourly average periods possible during a season.

Valid Hourly Averages (Filtered and Unfiltered) - The number of valid hourly averages collected during a season. The percentage data recovery represents the number of valid hourly averages compared to the total possible hourly averages.

Valid Hourly Averages (Filtered) - The number of valid hourly averages (excluding any data indicating meteorological interference) collected during a season. The percentage represents the number of valid hourly averages compared to the total possible hourly averages.

Filtered Data Percent of Filtered and Unfiltered Hourly Averages - This percentage collection efficiency represents the number of filtered hourly averages compared to the number of all valid hourly averages.

4.1.3.2 Events and Circumstances Influencing Data Recovery

Each seasonal report contains a brief discussion of events and circumstances that influence data recovery. An analysis summary table is also prepared (for all data and for all data excluding meteorological-influenced data) based on actual monitoring periods. The table lists for each site, site name and abbreviation, the number of seasonal hourly averages possible, the number and percentage of valid hourly averages for all data and for filtered data only, and the cumulative frequency distribution (10%, 50%, and 90% b_{scat} values) for all data and filtered data only. An example Analysis Summary Table is presented as Table 4-3.

Table 4-3

Example Analysis Summary Table

SITE	SITE ABRV	DATA RECOVERY: POSSIBLE HOURLY AVERAGES	DATA RECOVERY: VALID HOURLY AVERAGES (ALL DATA)	DATA RECOVERY: VALID HOURLY AVERAGES (FILTERED)	CUMULATIVE FREQUENCY DISTRIBUTION: b_{scat} (km^{-1}) UNFILTERED DATA 10%	50%	90%	b_{scat} (km^{-1}) FILTERED DATA 10%	50%	90%
ACADIA NP	ACAD	2184	2027 (93%)	1736 (79%)	.016	.028	.092	.016	.025	.066
BOUNDARY WATERS CANOE AREA W	BOWA	1186	709 (60%)	608 (51%)	.018	.029	.110	.017	.027	.071
DOLLY SODS W	DOSO	1143	1090 (95%)	737 (64%)	.018	.037	.286	.016	.029	.066
GREAT SMOKY MOUNTAINS NP	GRSM	2184	2072 (95%)	1619 (74%)	.021	.052	.221	.019	.041	.144
JARBIDGE W	JARB	2184	1920 (88%)	1665 (76%)	.013	.020	.043	.013	.019	.038
MAMMOTH CAVE NP	MACA	2184	2087 (96%)	1260 (58%)	.024	.073	.370	.022	.045	.409
MOUNT RAINIER NP	MORA	2184	2150 (98%)	1460 (67%)	.023	.050	.132	.022	.044	.109
OKEFENOKEE W	OKEF	1860	1267 (68%)	797 (43%)	.033	.079	.263	.030	.057	.136
UPPER BUFFALO W	UPBU	2184	1906 (87%)	1474 (67%)	.021	.076	4.160	.020	.054	.170

4.1.4 <u>References</u>

References are presented in two subsections: 1) Technical References, and 2) Related Reports and Publications. Technical references are those documents that are cited in the seasonal report. Related reports and publications include all prior reports pertaining to the monitoring program, produced by Air Resource Specialists, Inc. (ARS).

4.1.5 <u>Appendix A - Nephelometer Data Collection and Processing Procedures</u>

Each seasonal report contains an appendix that fully details nephelometer data collection and processing procedures. The following subsections, which are presented in the appendix, discuss these procedures.

4.1.5.1 On-Site Data Logging and Transmission

Nephelometer data transmittal from the site to ARS facilities is discussed. The data are transferred either by telephone modem directly from the site or through data collection platforms (DCPs) to the GOES satellite, to ARS via telephone modem. A full description of data collection procedures is included in SOP 4300, *Collection of Optical Monitoring Data (IMPROVE Protocol)*.

4.1.5.2 Daily and Weekly Processing Procedures

Detailed data collection and daily and weekly processing procedures performed at ARS facilities are described. This discussion includes the steps involved in reviewing data files for extraneous information, searching for problems that require corrective action, verifying the date and time of the transmitted data, and applying preliminary validity codes. Refer to TI 4400-5010, *Nephelometer Data Reduction and Validation (IMPROVE Protocol)*, for a complete discussion of data reduction procedures.

4.1.5.3 Seasonal Data Processing Procedures

Detailed discussions of the various processing and validation levels performed during each season are presented. Discussion includes file formats, validity codes applied during the various stages of processing (validation levels), theoretical concepts of uncertainty measurements, and identification of meteorological and optical interferences that affect the calculation of b_{scat} from nephelometer measurements. Figure 4-3 presents the nephelometer data processing flow chart.

4.2 ANNUAL DATA REPORTING

Annual reports contain seven (7) major sections:

1.0 Introduction
2.0 Data Collection and Reduction
3.0 Site Configuration
4.0 Data Summary Description
5.0 Nephelometer Data Summaries
6.0 Summary
7.0 References

The information and data presentation formats included in each section are summarized in the following subsections.

4.2.1 <u>Introduction</u>

The introduction section contains a conceptual overview of the purpose of the monitoring program and a description of the monitoring networks. It also includes a map of the United States, depicting locations of all nephelometer monitoring sites (see Figure 4-1).

4.2.2 <u>Data Collection and Reduction Procedures</u>

Each annual report contains detailed nephelometer data collection and processing procedures, identical to the appendix included in seasonal reports (refer to Section 4.1.5). Discussion includes data collection methods, data file review, data validation, application of validity codes, processing through various validation levels, and discussion of file formats, theoretical concepts of uncertainty measurements, and identification of meteorological and optical interferences that affect the calculation of b_{scat} from nephelometer measurements.

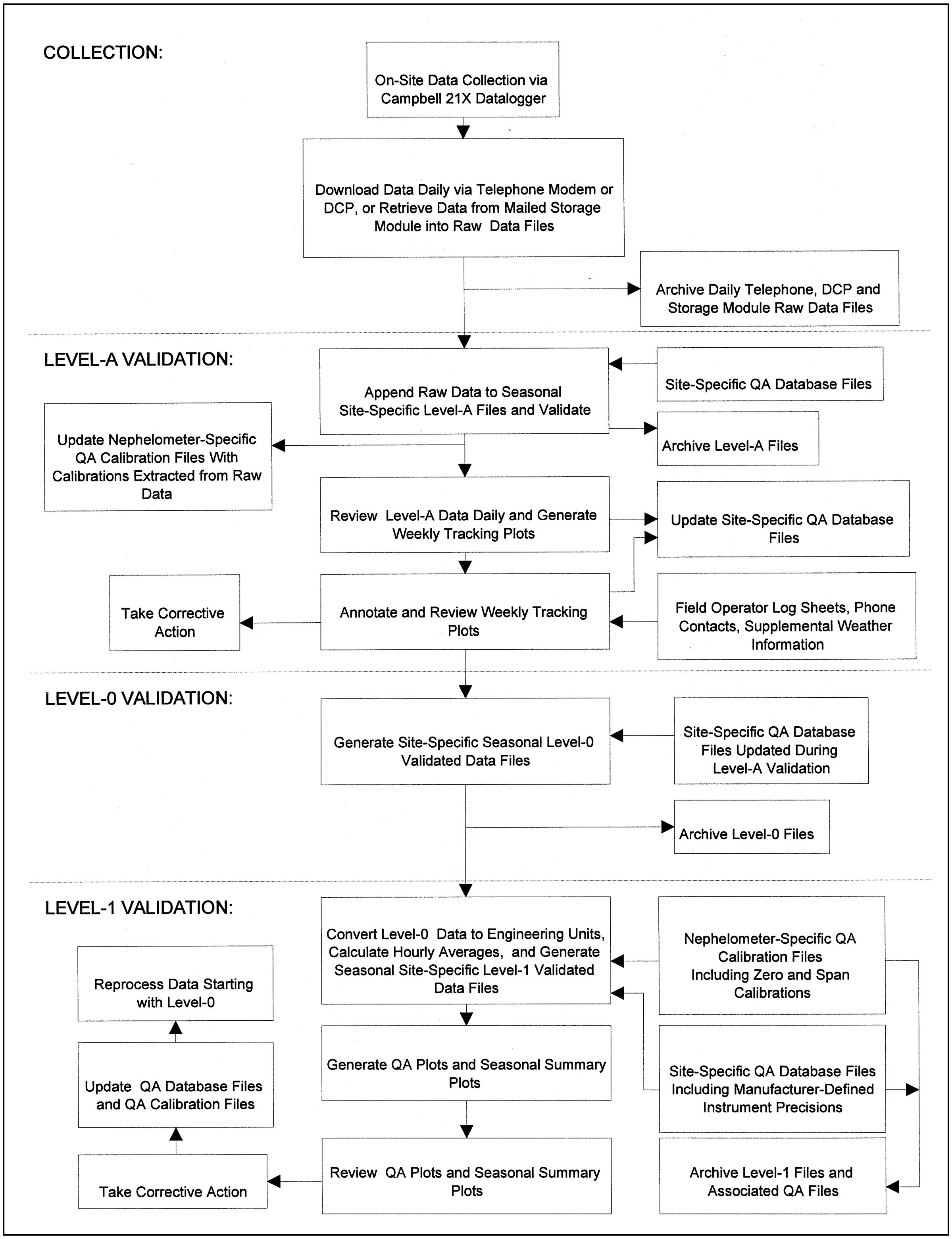


Figure 4-3. Nephelometer Data Processing Flow Chart.

4.2.3 Site Configuration

The site configuration section contains a brief discussion of instrumentation at each nephelometer site and basic principles of operation. A site specifications summary table is presented (see Table 4-2).

4.2.4 Data Summary Description

Each annual report contains a data summary description section describing seasonal and annual data summaries. Refer to Section 4.1.3 for a detailed discussion of seasonal summaries. Annual data summaries are prepared for each site that operated during the reporting period, and are based on a calendar year instead of season. An example Annual Nephelometer Data Summary is presented as Figure 4-4. The following is a detailed explanation of the contents of the data summaries and accompanies the summaries in each report. Annual Nephelometer Data Summaries include three data presentations:

- **Monthly Median Visual Air Quality** - Plot of median monthly b_{scat} for all data and for filtered data only. As the visual air quality improves, b_{scat} values decrease. A Rayleigh atmosphere is defined by a b_{scat} of approximately 0.01 km^{-1}.

- **Monthly Cumulative Frequency Summaries** - Table of cumulative frequency distribution average b_{scat} values for all data and for filtered data only. The 10%, 50%, and 90% values are presented. Also included are data recovery statistics (total possible readings, number and percent of collected readings, and number and percent of valid readings (both all data and filtered data only)).

- **Annual Frequency of Occurrence: Hourly Data** - This plot is a frequency distribution of hourly average b_{scat} values for all data and for filtered data only. The 10% to 90% values are plotted in 10% increments. Numerical values are presented in the adjacent cumulative frequency summary table.

For b_{scat}, the 10%, 50%, and 90% values can be interpreted as:

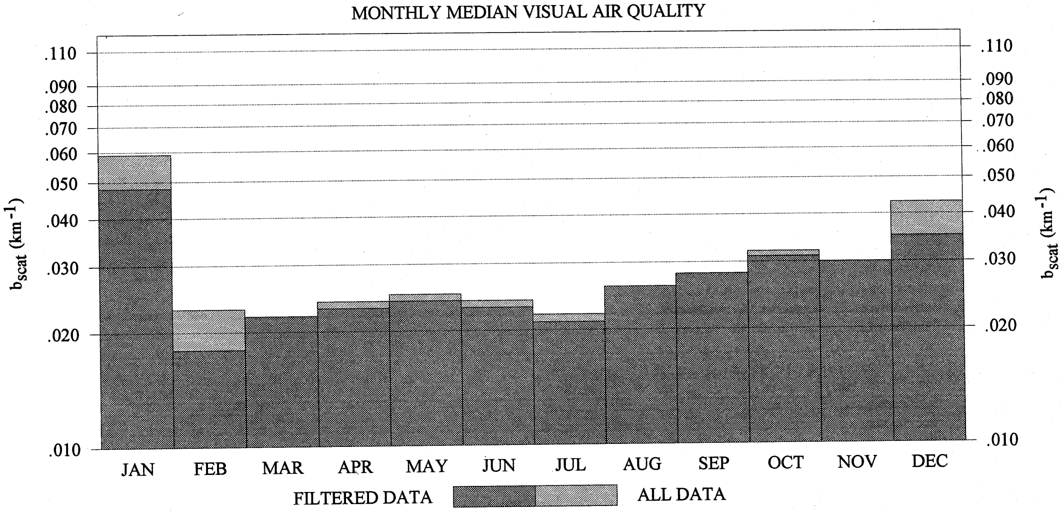
Value	Interpretation
10%	10% of the time the b_{scat} was less than or equal to the 10% value;
50%	Median value; 50% of the b_{scat} observations are less than the 50% value and 50% of the observations are greater than the 50% value; and
90%	90% of the time the b_{scat} was less than or equal to the 90% value (10% of the time it was greater than or equal to the 90% value).

4.2.5 Nephelometer Data Summaries

The data summary section presents first the seasonal summary plots, then the annual summary plots. Data recovery and cumulative frequency distribution tables follow, containing a summary of values for each season (see Table 4-3).

MOUNT RAINIER NATIONAL PARK, WASHINGTON
Annual Nephelometer Data Summary
All Data: January 1, 1992 - December 31, 1992

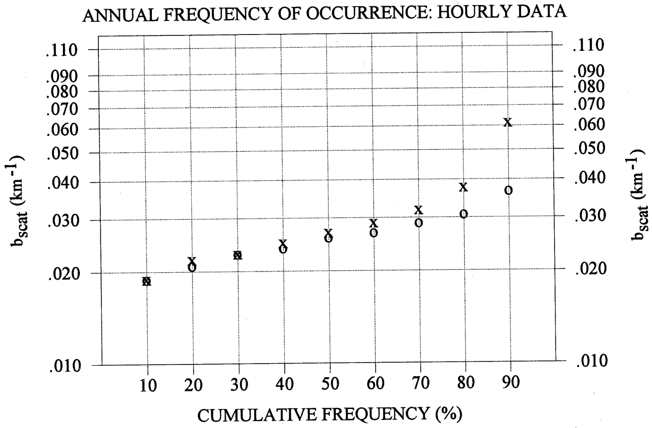
MONTHLY MEDIAN VISUAL AIR QUALITY



MONTHLY CUMULATIVE FREQUENCY SUMMARIES

		FILTERED DATA			ALL DATA			DATA RECOVERY STATISTICS						
		10%	50%	90%	10%	50%	90%	POSS.	COLLECTED		ALL		FILTERED	
MONTH	YEAR	b_{scat}	b_{scat}	b_{scat}	b_{scat}	b_{scat}	b_{scat}	NUM	NUM	%	NUM	%	NUM	%
JAN	1992	0.027	0.048	0.069	0.029	0.059	0.608	744	741	100	739	99	135	18
FEB	1992	0.015	0.018	0.031	0.015	0.023	0.076	696	693	100	692	99	371	53
MAR	1992	0.017	0.022	0.027	0.017	0.022	0.031	744	741	100	740	99	555	75
APR	1992	0.019	0.023	0.029	0.019	0.024	0.030	720	720	100	720	100	655	91
MAY	1992	0.019	0.024	0.030	0.020	0.025	0.033	744	744	100	744	100	554	74
JUN	1992	0.019	0.023	0.029	0.019	0.024	0.033	720	719	100	718	100	595	83
JUL	1992	0.017	0.021	0.028	0.017	0.022	0.030	744	742	100	741	100	654	88
AUG	1992	0.021	0.026	0.033	0.022	0.026	0.037	744	738	99	720	97	674	91
SEP	1992	0.025	0.028	0.035	0.025	0.028	0.036	720	708	98	707	98	685	95
OCT	1992	0.025	0.031	0.039	0.025	0.032	0.041	744	735	99	735	99	683	92
NOV	1992	0.024	0.030	0.038	0.024	0.030	0.044	720	717	100	717	100	623	87
DEC	1992	0.022	0.035	0.059	0.023	0.043	0.169	744	738	99	735	99	506	68
ALL DATA		0.019	0.026	0.037	0.019	0.027	0.062	8784	8736	99	8708	99	6690	76

ANNUAL FREQUENCY OF OCCURRENCE: HOURLY DATA



ANNUAL CUMULATIVE FREQUENCY SUMMARY

%	Filtered Data [o] b_{scat}	All Data [x] b_{scat}
10	.019	.019
20	.021	.022
30	.023	.023
40	.024	.025
50	.026	.027
60	.027	.029
70	.029	.032
80	.031	.038
90	.037	.062

D:01/20/94 1:48 p P:03/20/95

V1.01:3/20/95

Figure 4-4. Example Annual Nephelometer Data Summary.

4.2.6 Summary

The summary section provides a synopsis of the nephelometer network, including changes in operational techniques, and a general conclusion of the monitoring year in review.

4.2.7 References

Identical to the seasonal reports, references are presented in two subsections: 1) Technical References, and 2) Related Reports and Publications. Technical references are those documents that are cited in the annual report. Related reports and publications include all prior reports pertaining to the monitoring program, produced by ARS.

4.3 REPORT DISTRIBUTION

Reports are reviewed and approved by the project manager prior to preparation for distribution. When ready, ARS contacts the local project-specific COTR office for distribution requirements and provides the deliverable products as directed. The amount or type of deliverable product may vary with each report; for example, 15 seasonal reports and 5 annual reports are delivered to the NPS.

5.0 REFERENCES

AH Technical Services, 1987, Guidelines for Preparing Reports for the NPS Air Quality Division, September.

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**OPTICAL MONITORING DATA ARCHIVES**
TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4600**
DATE	**SEPTEMBER 1993**

AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
ORIGINATOR	Betsy Davis-Noland	
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QA MANAGER	Gloria S. Mercer	
OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
0.1	Minor text changes	December 1996	

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) is a guide to the archiving and maintenance of optical visibility monitoring data. The purpose of this SOP is to assure that the following data and information are secure and available:

- Nephelometer data
- Transmissometer data
- Associated meteorological data
- Supporting documentation

These archives are a historical record of both raw and processed data files and provide information that supports the documentation of existing conditions and trends in monitored areas. Duplicate archive tapes of digital data are stored off-site to prevent data loss.

The following technical instructions (TIs) provide detailed information regarding specific archive procedures:

- TI 4600-5000 *Nephelometer Data Archives (IMPROVE Protocol)*
- TI 4600-5010 *Transmissometer Data Archives (IMPROVE Protocol)*

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Ensure that archives are accessible, orderly, complete, and current.
- Inform the data archivist when data have been finalized and reported and are ready to be archived.
- Ensure that duplicate archives are properly stored off-site.

2.2 DATA COORDINATOR

The data coordinator shall:

- Archive raw transmissometer data on a monthly basis.
- Inform the data archivist of files to be archived on a monthly basis.
- Maintain supporting hard copy documentation.

2.3 DATA ARCHIVIST

The data archivist shall:

- Obtain and compile ASCII data files to be archived as directed by the project manager or data coordinator.
- Perform periodic archives.
- Prepare and maintain data archive files and records.
- Provide a list of archived file names to the project manager or data coordinator.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Required equipment and materials include computer equipment and software, digital data, and supporting documentation as discussed in the following subsections. Data Archive Request Forms are also needed to document the archiving process.

3.1 COMPUTER EQUIPMENT AND SOFTWARE

Optical visibility monitoring digital data archives are performed on IBM-PC compatible systems. Required computer system components and software include:

- An IBM compatible 386/486 computer system with VGA display and minimum 80 megabyte hard disk, and a 3.5" diskette drive, connected to the ARS computer network
- 3.5" diskettes
- GigaTrend's SL Digital Audio Tape (DAT) Drive
- 4mm DAT cartridges
- GigaTrend's ServerDat archiving/backup software
- ServerDat and WordPerfect software
- Hewlett Packard Laserjet 4 Printer
- Three-ring notebook
- Plastic storage pouches and storage boxes
- Storage cabinet

3.2 DIGITAL DATA

ASCII files, as specified on the Data Archive Request Form, must be available in a designated network on-line directory. All optical data will be handled as ASCII files.

3.3 SUPPORTING HARD COPY DOCUMENTATION

Supporting hard copy documentation for optical data is divided into two categories, site-based and instrument-based. All supporting documentation is archived on a continual basis. Equipment and materials for maintaining supporting documentation archives include:

- Three-ring notebooks
- Manila file folders
- Hanging file folders
- Standard file cabinets

4.0 METHODS

Archiving of raw digital data is performed on a monthly basis. Archiving of all raw and processed digital data is performed after data have been finalized and reported (generally seasonally for nephelometer data and annually for transmissometer data). All files are in ASCII format. Files are stored in their original formats (non-compressed) on magnetic tape and at least two copies of each archive tape are created. One tape is stored at ARS, the other(s) are stored off-site. Hard copies of supporting documentation are archived on a continual basis and stored in-office.

Procedures for archiving optical data are discussed in the following two (2) major subsections:

4.1 Nephelometer Data Archives
4.2 Transmissometer Data Archives

4.1 NEPHELOMETER DATA ARCHIVES

4.1.1 <u>Nephelometer Digital Data Archives</u>

Table 4-1 outlines the nephelometer monthly and seasonal archive process. Raw data files (site-specific daily files collected by telephone modem, DCP, or downloaded from storage modules) are archived monthly. File types to be archived seasonally include:

- Processed data files for each site; Level-A (XXXX_N), Level-0 (XXXX_N0), and Level-1 (XXXX_N11)
- Submit files for plotting data
- Constants file (NPROCESS.CON)
- Calibration files (QA files) for each instrument
- Code files (XXXX_C) for each site
- Data processing and plotting program executable and source code files

Specific nephelometer archive procedures are detailed in TI 4600-5000, *Nephelometer Data Archives (IMPROVE Protocol)*.

Table 4-1

Archiving Procedures for Nephelometer and Associated Digital Data
and Supporting Information

NEPHELOMETER DATA ARCHIVES				
RESPONSIBILITY	**TIMING**	**FILE TYPES ARCHIVED**	**MEDIA**	**DISPOSITION**
Monthly Archive of Nephelometer Digital Data				
Data Archivist as directed by the Data Coordinator	By the 10th of the month following the month of record	•Raw data files (site-specific daily files collected by telephone modem, DCP, or downloaded from storage modules)	Magnetic tape	•Two copies at ARS (archive storage cabinet and DCC)
Seasonal Archive of Nephelometer Digital Data				
Data Archivist as directed by the Project Manager	After data have been finalized and reported (within 90 days after the end of a season)	•Processed data files; Level-A (XXXX_N), Level-0 (XXXX_N0) and Level-1 (XXXX_N11) files •Submit files for plotting data • Constants file (NPROCESS.CON) •QA calibration files (SSS_N.QA) •QA database files (XXXX_C) •Data processing and plotting program executable and source code files (NGN_PULL, NGN_PLOT, NGN_SEAS, NGN_NSUM, NGN_QA)	Magnetic tape	•One copy at ARS •One copy off-site
Archive of Supporting Hard Copy Documentation				
Data Coordinator	Continuously	•Site specifications •Site servicing trip reports •Monitoring timelines •Data coordinator/site operator correspondence •Site operator log sheets •Instrument calibration and audit reports •Instrument maintenance logs •Weekly plots •Seasonal plots •Annual plots •Seasonal summary history forms •Seasonal uncertainty printouts	Hard copies	•On file at ARS or ARS storage

4.1.2 Nephelometer Supporting Hard Copy Documentation Archives

Supporting hard copy documentation is archived on a continual basis. Nephelometer monitoring support documentation includes the following:

- Site specifications
- Site servicing trip reports
- Monitoring timelines
- Data coordinator/site operator correspondence
- Site operator log sheets
- Instrument calibration and audit reports
- Instrument maintenance logs
- Weekly, seasonal, and annual data plots
- Seasonal summary history forms
- Seasonal uncertainty printouts

Specific nephelometer archive procedures are detailed in TI 4600-5000, *Nephelometer Data Archives (IMPROVE Protocol)*.

4.2 TRANSMISSOMETER DATA ARCHIVES

4.2.1 Transmissometer Digital Data Archives

Table 4-2 outlines the transmissometer monthly and seasonal archive process. Raw data files (daily Wallops files) are archived monthly. File types to be archived seasonally include:

- Processed data files for each site; Level-A (XXXX_T), Level-0 (XXXX_T0), and Level-1 (XXXX_T11, XXXX_T1W, and XXX_T14)
- Submit files for plotting data
- Constants file (TPROCESS.CON)
- Lamp calibration files (XXXX_L) for each instrument
- Code files (XXXX_C) for each site
- Data processing and plotting program executable and source code files

Specific transmissometer archive procedures are detailed in TI 4600-5010, *Transmissometer Data Archives (IMPROVE Protocol)*

Table 4-2

Archiving Procedures for Transmissometer and Associated Digital Data and Supporting Information

TRANSMISSOMETER DATA ARCHIVES				
RESPONSIBILITY	**TIMING**	**FILE TYPES ARCHIVED**	**MEDIA**	**DISPOSITION**
Monthly Archive of Transmissometer Digital Data				
Data Coordinator	By the 10th of the month following the month of record	•Raw data files (Wallops files)	3.5" diskette	•One copy at ARS (DCC)
Data Archivist as directed by the Data Coordinator	By the 10th of the month following the month of record	•Raw data files (Wallops files)	Magnetic tape	•Two copies at ARS (archive storage cabinet and DCC)
Periodic Archive of Transmissometer Digital Data				
Data Archivist as directed by the Project Manager	After data have been finalized and reported	•Processed data files; Level-A (XXXX_T), Level-0 (XXXX_T0) and Level-1 (XXXX_T11, XXXX_T1W, and XXXX_T14) files •Submit files for plotting data • Constants file (TPROCESS.CON) •Lamp calibration files (XXXX_L) •Code files (XXXX_C) •Data processing and plotting program executable and source code files (WALLOPS4, STRIP_T, APPEND_T, PROCESS.BAT, WIN_TSUM)	Magnetic tape	•Two copies at ARS (Archive Storage Cabinet and DCC) •One copy off-site
Archive of Supporting Hard Copy Documentation				
Data Coordinator	Continuously	•Site specifications •Monitoring timelines •Data coordinator/site operator correspondence •Site operator log sheets •Instrument calibration and audit reports •Instrument maintenance logs •Bi-monthly plots •Seasonal plots •Annual plots •Seasonal summary history forms	Hard copies	•On file at ARS or ARS storage

4.2.2 Transmissometer Supporting Hard Copy Documentation Archives

Supporting hard copy documentation is archived on a continual basis. Transmissometer monitoring support documentation includes the following:

- Site specifications
- Monitoring timelines
- Data coordinator/site operator correspondence
- Site operator log sheets
- Instrument calibration and audit reports
- Instrument maintenance logs
- Bi-monthly, seasonal, and annual plots
- Seasonal summary history forms

Specific transmissometer archive procedures are detailed in TI 4600-5010, *Transmissometer Data Archives (IMPROVE Protocol)*.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**NEPHELOMETER DATA ARCHIVES (IMPROVE PROTOCOL)**
TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4600-5000**
DATE	**MARCH 1995**

AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
ORIGINATOR	J. Carter Blandford	
PROJECT MANAGER	James H. Wagner	
PROGRAM MANAGER	David L. Dietrich	
QA MANAGER	Gloria S. Mercer	
OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) is a guide to archiving nephelometer-based optical visibility monitoring data. The purpose of this TI is to assure that data and supporting information are secure and available. This TI is referenced by SOP 4600, *Optical Monitoring Data Archives*.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Ensure that archives are accessible, orderly, complete, and current.
- Issue a Data Archive Request Form to the data archivist when data have been finalized and reported. This is typically performed at the end of each season.
- Document and distribute duplicate archive tapes to off-site locations.

2.2 DATA COORDINATOR

The data coordinator shall:

- Issue a Data Archive Request Form to the data archivist on a monthly basis.
- Maintain archives of supporting hard copy documentation on a continual basis.

2.3 DATA ARCHIVIST

The data archivist shall:

- On at least a monthly basis, archive all raw nephelometer and associated meteorological data files to magnetic tape.
- Archive finalized and reported data (processed data and associated files) to magnetic tape (generally seasonally).
- Obtain and compile data files to be archived as described on the Data Archive Request Form.
- Perform archives as described in this TI.
- Maintain data archive files and records.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Required equipment and materials include computer equipment and software, digital data, and supporting documentation as discussed in the following subsections. Data Archive Request Forms are also needed to document the archiving process.

3.1 COMPUTER EQUIPMENT AND SOFTWARE

Optical visibility monitoring digital data archives are performed on IBM-PC compatible systems. Required computer system components and software include:

- An IBM compatible 386/486 computer system with VGA display and minimum 80 megabyte hard disk, and a 3.5" diskette drive, connected to the ARS computer network
- GigaTrend's SL Digital Audio Tape (DAT) Drive
- 4mm DAT cartridges
- GigaTrend's ServerDat archiving/backup software
- ServerDat and WordPerfect software
- Hewlett Packard Laserjet 4 Printer
- Three-ring notebook
- Plastic storage pouches and storage boxes
- Storage cabinet

3.2 DIGITAL DATA

ASCII files of nephelometer data (raw, Level-A, Level-0, or Level-1) as specified on the Data Archive Request Form, must be available in a designated network on-line directory. All nephelometer data will be handled as ASCII files.

3.3 SUPPORTING HARD COPY DOCUMENTATION

Supporting hard copy documentation for nephelometer monitoring is divided into two categories, site-based and instrument-based. All supporting documentation is archived on a continual basis. Equipment and materials for maintaining supporting documentation archives include:

- Three-ring notebooks
- Manila file folders
- Hanging file folders
- Standard file cabinets

4.0 METHODS

Table 4-1 outlines archiving procedures for nephelometer and associated digital data and supporting information. Details of each archive procedure are described in the following four (4) major subsections:

4.1 Monthly Archive of Nephelometer Digital Data
4.2 Seasonal Archive of Nephelometer Digital Data
4.3 Digital Data Archiving
4.4 Supporting Hard Copy Documentation Archiving

4.1 MONTHLY ARCHIVE OF NEPHELOMETER DIGITAL DATA

Raw data files are archived on a monthly basis. At the beginning of each month following the month of record, raw data files downloaded via telephone modem, DCP, or storage module, are archived on magnetic streamer tape.

Raw data files (site-specific daily files) are located on the ARS computer network. The naming convention for the raw data files is:

XXXXYYQR.DDD

where

XXXX =	Site code
YY	= Last two digits of the year
Q	= Data source (D = download, S = storage module)
R	= Daily file serial number (A = 1st, 0 = 2nd, 1 = 3rd, etc.)
DDD	= Julian date

Monthly archiving of raw data files is a two-part process, as detailed in Section 4.3. First, the data coordinator issues a Data Archive Request Form to the data archivist. Second, with the information provided on the form, the data archivist archives the requested data set.

4.2 SEASONAL ARCHIVE OF NEPHELOMETER DIGITAL DATA

As illustrated in Table 4-1, a series of processed data, submit, constants, calibration, database, and executable files are archived on magnetic streamer tape seasonally, following final data processing. Seasonal nephelometer data archiving is a two-part process, similar to monthly archiving. First, the project manager issues a Data Archive Request Form to the data archivist. Second, with the information provided on the form, the data archivist archives the requested data set.

Processed data files (Level-A, Level-0, and Level-1) are located on the ARS computer network, on "G:\USERS\NEPH\NETWORK\YYS" (where "YY" is the year and "S" is the season, e.g., 933 signifies the third season (summer) of 1993). The naming convention for these files is:

Table 4-1

Archiving Procedures for Nephelometer and Associated Digital Data
and Supporting Information

NEPHELOMETER DATA ARCHIVES				
RESPONSIBILITY	**TIMING**	**FILE TYPES ARCHIVED**	**MEDIA**	**DISPOSITION**
Monthly Archive of Nephelometer Digital Data				
Data Archivist as directed by the Data Coordinator	By the 10th of the month following the month of record	•Raw data files (site-specific daily files collected by telephone modem, DCP, or downloaded from storage modules)	Magnetic tape	•Two copies at ARS (archive storage cabinet and DCC)
Seasonal Archive of Nephelometer Digital Data				
Data Archivist as directed by the Project Manager	After data have been finalized and reported (within 90 days after the end of a season)	•Processed data files; Level-A (XXXX_N), Level-0 (XXXX_N0) and Level-1 (XXXX_N11) files •Submit files for plotting data • Constants file (NPROCESS.CON) •QA calibration files (SSS_N.QA) •QA database files (XXXX_C) •Data processing and plotting program executable and source code files (NGN_PULL, NGN_PLOT, NGN_SEAS, NGN_NSUM, NGN_QA)	Magnetic tape	•One copy at ARS •One copy off-site
Archive of Supporting Hard Copy Documentation				
Data Coordinator	Continuously	•Site specifications •Site servicing trip reports •Monitoring timelines •Data coordinator/site operator correspondence •Site operator log sheets •Instrument calibration and audit reports •Instrument maintenance logs •Weekly plots •Seasonal plots •Annual plots •Seasonal summary history forms •Seasonal uncertainty printouts	Hard copies	•On file at ARS or ARS storage

Type	Naming Convention	Description
Level-A	XXXX_N.YYS	XXXX = Site code N = Nephelometer data YY = Year S = Season
Level-0	XXXX_N0.YYS	XXXX = Site code N = Nephelometer data 0 = Level-0 data YY = Year S = Season
Level-1	XXXX_N11.YYS	XXXX = Site code N = Nephelometer data 1 = Level-1 data 1 = Hourly data

Other supporting files to be archived include:

Type	Naming Convention	Description
Submit files	SEASSUM.SBM	Plotting information
Constants file	NPROCESS.CON	Site specifications
QA Calibration files	SSS_N.QA	Instrument-specific calibration information
QA Database files	XXXX_C	Quality assurance validity and precision codes
Data processing source code and executable files	NGN_PULL NGN_PLOT NGN_SEAS NGN_QA NGN_NSUM	Data collection files Level-A plotting program files Level-0 and Level-1 validation program files QA file summaries program files Seasonal summary plot program files

Refer to TI 4400-5010, *Nephelometer Data Reduction and Validation (IMPROVE Protocol)* for detailed discussions on each data file type.

The archiving procedure using the seasonal files is identical to monthly archiving of daily files (see Section 4.1). A Data Archive Report is produced and disposition of tapes and archive records parallel monthly archiving procedures.

4.3 DIGITAL DATA ARCHIVING

Digital data archiving involves first completing a Data Archive Request Form, then having the data archivist perform the archiving.

4.3.1 Data Archive Request Form

The data coordinator (for monthly archiving) or project manager (for seasonal archiving) issues a Data Archive Request Form to the data archivist. Figure 4-1 is an example Data Archive Request Form. The following information should be completed by the person requesting the archive:

- Current date
- Name of person to receive the data archive request (the data archivist)
- Name of person who initiated the data archive request (the data coordinator)
- Project name or account codes
- Data period (e.g., March 1993)
- Number of archive tape copies required
- A general description of the data (e.g., "daily, raw digital data files for nephelometer monitoring from the month of March 1993, for the IMPROVE project")
- Note if a new archive tape is to be created or if an existing tape is to be appended or overwritten
- Disposition of the tapes
- Names of the specific files to be archived using an attached directory listing of the files if needed

The data archivist will archive the data within two weeks after receiving the Data Archive Request Form and will complete the form with the following information:

- Archive date
- Number of archive tapes made
- Tape label names
- Disposition of the tapes
- Additional notes concerning the archive

4.3.2 Archiving Procedure

4.3.2.1 The ServerDat Program

The data archivist obtains and compiles all files to be archived, then performs the archive as the following steps detail:

Air Resource Specialists, Inc.

DATA ARCHIVE REQUEST

Date: ____________________ Project/Study: ____________________

To: ____________________ Period: ____________________

From: ____________________ # of tape copies: ____________________

General Data Description: ____________________

New Tape ______ or Label of Tape to Append: ____________________

Disposition: ____________________

Files to be archived (include full path) or attach listing:

To Be Completed by Data Archivist

Archive date: ____________ # of tapes per copy: __________ # of copies: ________

Tape Label(s): ____________________

Disposition: ____________________

Notes: ____________________

archive.req 12/94

Figure 4-1. Data Archive Request Form.

1) If using a new tape, initialize it before proceeding with the archive. To initialize a 4mm DAT tape, hold the **EJECT** button while inserting the tape into the GigaTrend SL tape drive. Release the button when the left LED flashes. When the orange LED lights, press the **EJECT** button again. When the initialization is complete, the tape will automatically eject.

2) If using a tape that has previously been used or initialized, insert the 4mm DAT archive tape into the GigaTrend SL tape drive.

3) From any ARS network work station, enter the ServerDat program by typing **SD** at the DOS prompt.

4) Select **SCHEDULE ATTENDED JOBS** from the "Main Menu."

5) Select **BACK UP TO TAPE** from the "Attended Operations Menu."

6) Select **SPEED ENTRY** from the "Selection Method Menu."

7) Select the volume that contains the source files (SYS is drive F:, VOL1 is drive G:).

8) Mark the directories/files to archive by highlighting the directory/file name and pressing **F5**. Press **F2** when all directories/files to archive have been marked.

9) Fill in the "Attended Back Up To Tape Job Entry Form" on the computer screen display (see Figure 4-2) with the following information:

   - Tape name (maximum of 24 characters). The tape name should be as descriptive as possible and include the instrument/data type and period of record. For example, "Raw Neph Data - 03/94." This name is written to the tape header if new, or matched if appending. Place an asterisk (*****) here if this is an append.

   - Mode (append or overwrite).

   - The report directory and name (the report lists the archived files and any error messages generated during the job). This file will be used later for hard copy documentation of the archive.

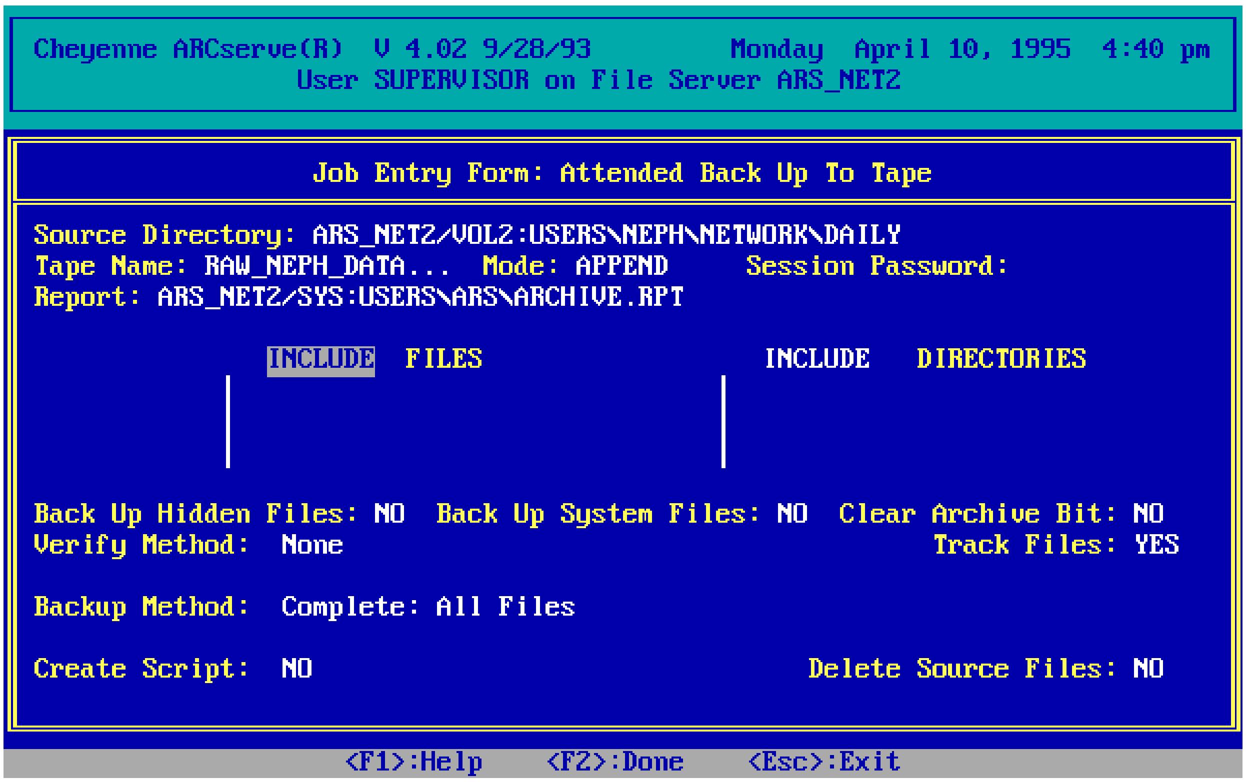
   The remaining fields on the "Job Entry Form" should hold the following values:

   - Include Files - This can be used to selectively archive certain files by standard DOS "wild card" criteria. If all files in the directories marked in Step 8 are to be archived, leave this field blank.

   - Back Up Hidden Files = **NO**

   - Back Up System Files = **NO**

   - Clear Archive Bit = **NO**



Cheyenne ARCserve(R) V 4.02 9/28/93   Monday April 10, 1995 4:40 pm
User SUPERVISOR on File Server ARS_NET2

Job Entry Form: Attended Back Up To Tape

Source Directory: ARS_NET2/VOL2:USERS\NEPH\NETWORK\DAILY
Tape Name: RAW_NEPH_DATA... Mode: APPEND   Session Password:
Report: ARS_NET2/SYS:USERS\ARS\ARCHIVE.RPT

INCLUDE FILES   INCLUDE   DIRECTORIES

Back Up Hidden Files: NO Back Up System Files: NO Clear Archive Bit: NO
Verify Method: None   Track Files: YES

Backup Method: Complete: All Files

Create Script: NO   Delete Source Files: NO

<F1>:Help   <F2>:Done   <Esc>:Exit

Figure 4-2. Attended Backup to Tape Job Entry Form (Screen Display).

- Verify Method = **COMPARE TAPE TO DISK**
- Back Up Method = **COMPLETE: ALL FILES**
- Track Files = **YES**
- Create Script = **NO**
- Back Up System Files = **NO**
- Clear Archive Bit = **NO**
- Verify Method = **COMPARE TAPE TO DISK**
- Back Up Method = **COMPLETE: ALL FILES**
- Track Files = **YES**
- Create Script = **NO**
- Delete Source Files = **YES** or **NO**. Select **YES** only if the files are no longer needed on the network drive. Use caution with this option.

10) Press **F2** to begin the job once the "Job Entry Form" is complete. The program displays the archiving activity on the screen in real-time, giving the total number of files, bytes and blocks, and the specific file and its size as the job is processed.

11) If the "Delete Source Files" field in the "Job Entry Form" was set to "Yes," the program will ask whether or not to delete the source files. The deletion can be confirmed if the files are no longer needed on the network. The source files should not be deleted if additional archives are required.

12) Press any key when the job is done to return to the "Attended Operations Menu."

13) Press the **EJECT** button on the tape drive to remove the tape cartridge.

14) Label both the tape cartridge and the cartridge case with the tape name (refer to Step 9).

15) Repeat all steps to create duplicate tapes.

4.3.2.2 The Data Archive Report

The Data Archive Report is the file named in Step 9 in Section 4.3.2.1. The report can be printed by running ARCHRPT.BAT, a DOS batch file that loads WordPerfect and runs a WordPerfect macro to reformat and print the report. To run the batch file:

- Type at the network DOS prompt **ARCHRPT**, then press the "Enter" key.
- When prompted, enter the report file name as entered in Step 9 in Section 4.3.2.1.

The report will be sent to the HP Laserjet 4 printer. Photocopy the report and store one copy with each archive tape. Store an additional copy in the Data Archive Log notebook.

4.3.2.3 Disposition of Tapes and Data Archive Records

Archive tapes and records are distributed as follows:

- One copy of each archive tape is stored at ARS in the archive storage cabinet in the DCC. The tape is placed in a plastic protector pouch with a copy of the archive report and Data Archive Request Form, then into a storage box with other archive tapes. The storage box will reside in the archive storage cabinet at ARS for no less than five years.

- One copy of the archive tape is returned to the project manager with a copy of the archive report and a copy of the completed Data Archive Request Form for off-site storage.

- One copy of the archive report and one copy of the completed Data Archive Request Form will be placed in the Data Archive Log notebook. The Data Archive Log notebook resides in the archive storage cabinet in the computer room.

- Any additional copies of the tape will be distributed as indicated on the Data Archive Request Form.

4.3.2.4 Reported Nephelometer Data Archive Tape Labeling Convention

Each reported nephelometer data archive tape will be labeled using the following convention:

- The first eight characters will be "NEPHRPT_."

- Characters 9 through 13 will denote the month and year the report was issued using a three-letter abbreviation for the month (JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC) and two digits for the year (94, 95, 96, etc.).

- Character number 14 will be an underscore (_).

- Characters 15 through 21 will denote the reporting period; two digits for the beginning season year (i.e., 93, 94, 95) followed by a single digit to indicate the season (1=winter, 2=spring, 3=summer, 4=fall). Next will be a dash (-) followed by two digits for the ending season year and one digit for the ending season.

- The final two characters are an underscore (_) and a number representing the tape copy number.

For example, copy one of the reported nephelometer archive tape for a report issued in September of 1994 covering the period of Summer 1993 through Spring 1994 would be named: NEPHRPT_SEP94_933-942_1.

4.4 SUPPORTING HARD COPY DOCUMENTATION ARCHIVING

Supporting hard copy documentation is archived continually. The documentation is located in the DCC in labeled three-ring notebooks and in labeled file cabinets.

4.4.1 Site-Based Nephelometer Supporting Hard Copy Documentation Archives

Site-based nephelometer monitoring support documentation includes:

- Site specifications (refer to TI 4070-3000, *Installation of Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)* and TI 4070-3001, *Site Documentation for Optec NGN-2 Nephelometer Systems)*)
- Monitoring timelines (refer to TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*)
- Data coordinator/site operator correspondence (refer to TI 4100-3100, *Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*)
- Site operator log sheets (refer to TI 4100-3100, *Routine Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*)
- ARS trip reports from yearly site visits (refer to TI 4115-3005, *Annual Site Visit Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol)*)
- Weekly plots (refer to TI 4400-5010, *Nephelometer Data Reduction and Validation (IMPROVE Protocol)*)
- Seasonal summary plots (refer to TI 4500-5000, *Nephelometer Data Reporting (IMPROVE Protocol)*)
- Annual summary plots (refer to TI 4500-5000, *Nephelometer Data Reporting (IMPROVE Protocol)*)
- Seasonal summary history forms
- Seasonal uncertainty printouts (refer to TI 4400-5010, *Nephelometer Data Reduction and Validation (IMPROVE Protocol)*)

4.4.2 Instrument-Based Nephelometer Supporting Hard Copy Documentation Archives

Instrument-based nephelometer monitoring support documentation includes:

- Instrument calibration (refer to TI 4200-2000, *Calibration of Optec NGN-2 Nephelometers (IMPROVE Protocol)*)
- Instrument maintenance logs (refer to TI 4100-3400, *Nephelometer Annual Laboratory Maintenance (IMPROVE Protocol)*)
- Field audit reports (refer to SOP 4700, *Optec NGN-2 Nephelometer Audit Procedures (IMPROVE Protocol)*)

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**OPTEC NGN-2 NEPHELOMETER AUDIT PROCEDURES (IMPROVE PROTOCOL)**
TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4700**
DATE	**JANUARY 1995**

AUTHORIZATIONS

TITLE	NAME	SIGNATURE
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OTHER		

REVISION HISTORY

REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
1.0	Up-scale calibration using upgraded valve	March 1995	

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) describes the procedures for conducting a performance audit of an Optec NGN-2 nephelometer. The purpose of the audit is to assess the measurement process under normal operating conditions without any special preparation or adjustment of the system. The audit is used to:

- Ensure the integrity of the data, and
- Assess the data for accuracy.

The audit of an Optec NGN-2 nephelometer includes:

- Performing a zero and upscale calibration using the existing station calibration system.
- Performing a zero and upscale calibration using the audit calibration system.
- Comparing the audit calibration to the station calibration to assess the validity of operator-performed calibrations.
- Comparing the audit calibration to the installation calibration to assess how the instrument has changed since installation.

Nephelometers are typically audited at least once a year, but can be audited at any time. This standard operating procedure is intended for use by independent auditors who understand general instrument audit concepts and have their own audit equipment and audit documentation form(s).

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Coordinate with the independent auditor regarding audit schedules, procedures, calibration constants, and required supplies.
- Review all audit results.
- Direct appropriate corrective action if indicated by the audit results.
- Review and approve any changes to audit procedures.

2.2 INDEPENDENT AUDITOR

The independent auditor shall:

- Perform all required audits.
- Document the audit results on the appropriate form(s).
- Forward audit results to the ARS data coordinator and other identified project personnel.

2.3 DATA COORDINATOR

- Enter the audit results into the quality assurance database.
- Coordinate and/or perform any corrective actions as indicated by the audit results.

2.4 SITE OPERATOR

The site operator shall assist the auditor.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Two different configurations of the internal span gas valve exist in operational Optec NGN-2 nephelometers: small orifice valve and large orifice valve. Span gas flow rates during calibrations or audits will vary depending on the valve configuration. Note that the nephelometers with the large orifice valve can be distinguished by a circular brass fitting with allen screws attached at the span gas entry port. The large orifice system is the preferred configuration and nephelometers should be upgraded with this configuration if possible.

The following materials are required for audit upscale and zero calibrations:

- Audit Upscale Calibration System

  - Calibration span gas (typically a 30 lb. non-refillable tank of DuPont SUVA-134a refrigerant)

  - A pressure regulator capable of providing tight regulation at low pressure (2 psi) and an adjustable flowmeter compatible and calibrated for use with the span gas. (Suggested regulator - Air Products MN E11-N510B. Suggested flowmeter (rotameter) - Cole Parmer MN N014-96ST).

  - Calibration gas hoses and fittings to connect the tank, regulator, rotameter, and nephelometer (see Figure 3-1).

- Audit Zero Calibration System (2 options):

  Option 1 - Zero value determined with an independent zero air supply (preferred option)

  - Zero air supply capable of providing at least 4 lpm of particle-free air at 2 psi.

  - Zero air supply hose (approximately 15 feet long)

  - Nephelometer zero air filter assembly without the filter cartridge installed

  Option 2 - Zero value determined using the nephelometer's internal zero air system pump and tubing with an independent audit filter

  - Nephelometer zero air filter assembly with audit filter cartridge (0.3 micron filter)

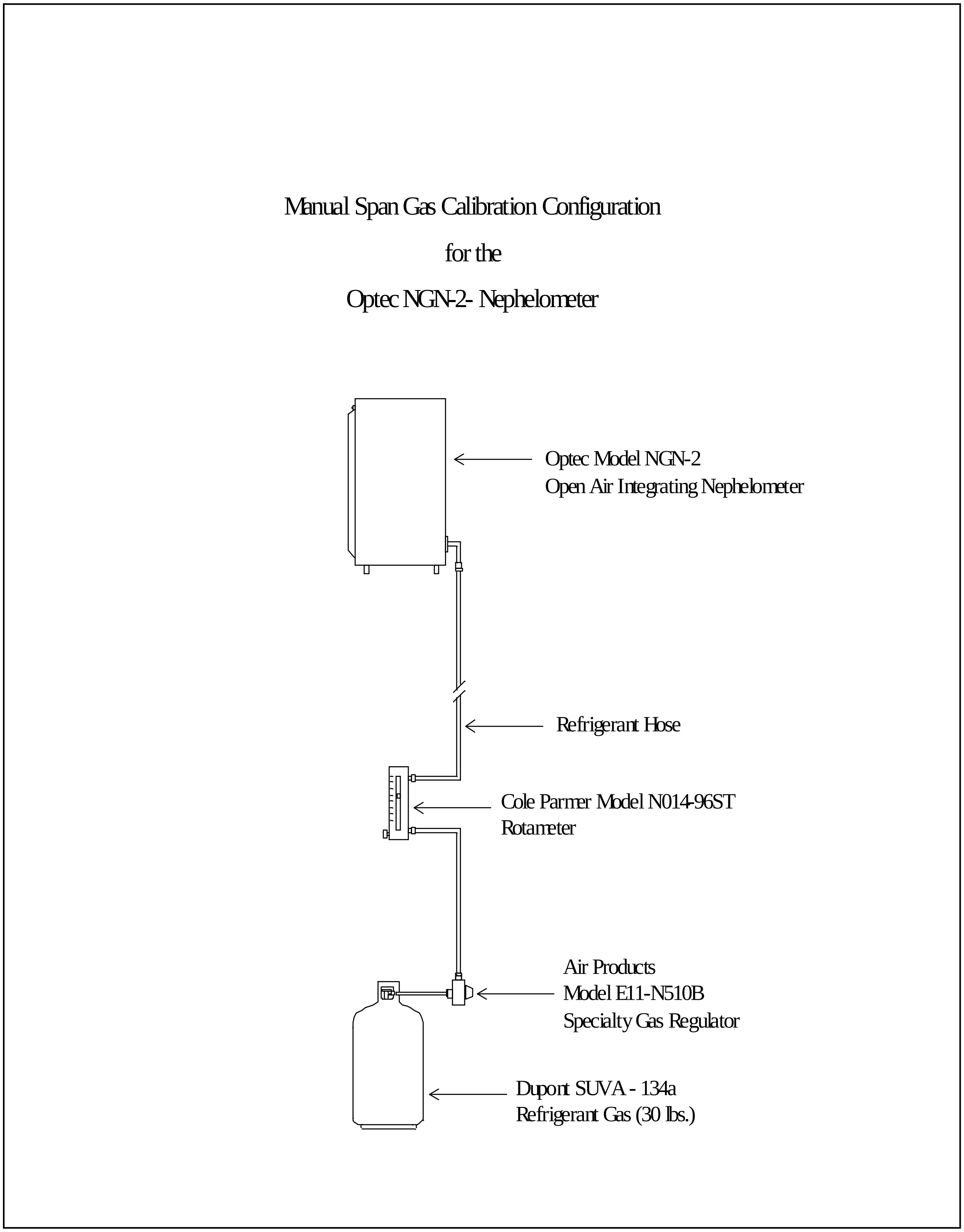

Figure 3-1. Manual Span Gas Calibration/Audit Configuration
for the Optec NGN-2 Nephelometer.

- TI 4200-2000, Calibration of Optec NGN-2 Nephelometers (IMPROVE Protocol)

- Audit forms and pen or pencil

- Flat-blade screwdriver and pliers for removing the station calibration gas hose from the nephelometer calibration inlet

- Lint-free cloth for use during the nephelometer inspection

4.0 METHODS

This section describes the nephelometer audit, and includes five (5) major subsections:

4.1 Pre-Inspection Audit Calibration
4.2 Nephelometer Inspection
4.3 Post-Inspection Audit Calibration
4.4 Operational Configuration Verification
4.5 Audit Results Report

Information regarding datalogger access for viewing nephelometer outputs is included in TI 4100-3100, Routine Site Operator Maintenance Procedures for Optec NGN-2 Nephelometer Systems (IMPROVE Protocol), and TI 4200-2000, Calibration of Optec NGN-2 Nephelometers (IMPROVE Protocol).

4.1 PRE-INSPECTION AUDIT CALIBRATION

The pre-inspection audit calibration is performed before physical examinations of the nephelometer clean air filter and light trap are performed. The pre-inspection calibration represents the state of the instrument upon arrival and includes the following:

- Nephelometer physical condition check

- Nephelometer calibration using station calibration system

- Nephelometer calibration using audit calibration system

4.1.1 Physical Condition Check

Verify that the nephelometer is in good physical condition before attempting to check the calibration. Verify the following:

- Proper operation of the power supply

- Unobstructed nephelometer door (i.e., free of obstructions such as ice or packed snow)

4.1.2 Calibration Using Station Calibration System

The calibration procedures using the station calibration system (nephelometer zero air filter and station calibration gas) are identical to those performed at regular intervals by the site operator as described in TI 4200-2000, Calibration of Optec NGN-2 Nephelometers (IMPROVE Protocol). The procedures include:

POWER-ON SELF TEST (POST)

The nephelometer performs a Power-On Self Test (POST) followed by an automatic zero and spank check when it is powered up. The POST sequence is as follows:

- Door closes
- Door opens
- Lamp turns on
- Fan turns on and off
- Internal solenoid turns on and off
- Clean air pump turns on and off
- Internal span gas valve turns on and off
- Fan turns on, solenoid turns on
- One-minute sample reading is taken
- Lamp turns off and door closes

UPSCALE CALIBRATION

Following the POST, the upscale/zero calibration sequence begins with a 20-minute upscale calibration. The upscale calibration requires that a source of regulated calibration gas (typically SUVA 134a) be supplied to the nephelometer during the calibration process. The following procedures are used to perform the upscale calibration:

- Connect the calibration gas hose from the nephelometer to the output connector (top) of the Cole Parmer MN N014-96ST flowmeter.
- Connect the flowmeter input hose (bottom) to the calibration gas regulator output connector.
- Open the calibration gas tank valve fully, then turn the valve back 1/4 to 1/2 turn.
- Reset the nephelometer by interrupting power to the nephelometer for five seconds.

- Observe the Power-On Self Test (POST). Document the results of the POST. Approximately 5 seconds after the door closes, the span gas valve will open. The pressure regulator and flowmeter settings can only be adjusted while the valve is open.

- Adjust the pressure regulator control valve to provide 2 psi to the nephelometer.

- Adjust the flowmeter (rotameter) as follows:

  1. For large orifice valves, adjust the rotameter to 4 lpm (corrected) of span gas. Use settings of approximately 40 mm when using the suggested Cole Parmer rotameter. Check the individual rotameter calibration for the actual value.

  2. For small orifice valves, adjust the rotameter to greater than 2 lpm (4 lpm optimal). If the flow cannot be adjusted to greater than 2 lpm, the valve is suspect and should be replaced or upgraded to a larger orifice configuration.

- Wait 20 minutes for the upscale calibration to complete. At the end of the upscale calibration, the nephelometer door will open. Record the results of the upscale calibration from the following nephelometer outputs:

  - Upscale calibration (counts) and related parameters on the serial channel

  - Upscale calibration value (1 mVDC = 1 count) on analog channel 1

- TURN THE CALIBRATION GAS TANK VALVE COMPLETELY OFF.

- Disconnect the calibration gas hose from the flowmeter. Place hose caps or plugs on the open ends of the hose and flowmeter.

- The nephelometer door will stay open for one minute to exhaust the calibration gas. After the minute, the door will close and the zero calibration will begin.

ZERO CALIBRATION

Following the one-minute calibration gas purge, the 15-minute zero calibration begins. The nephelometer circulates air in the measurement chamber through the 0.3 micron filter to perform the zero calibration. The following procedure describes the zero calibration:

- Wait 15 minutes for the zero check to complete. At the end of the zero calibration, the nephelometer door will open and the nephelometer will begin taking ambient readings. Record the results of the zero calibration from the following nephelometer outputs:

  - Zero calibration (counts) and related parameters on the serial channel

  - Zero calibration (1 mVDC = 1 count) on analog channel 1

  The nephelometer will begin operating in ambient mode upon completion of the zero and span check.

4.1.3 Calibration Using Audit Calibration System

The audit calibrations should be performed with an independent source of calibration gas to yield an upscale value and one of two options to yield a zero air value:

Option 1: Zero value determined with an independent zero air supply (preferred option)

Option 2: Zero value determined using the nephelometer's internal zero air system pump and tubing with an independent audit filter

The audit procedures are the same as those detailed in Section 4.1.2, Calibration Using Station Calibration System, except for the following:

Option 1: Zero value determined with an independent zero air supply

- Replace the nephelometer zero air filter assembly with the empty audit assembly.
- Disconnect the station upscale calibration system from the nephelometer calibration gas inlet.
- Attach the audit upscale calibration system to the nephelometer calibration gas inlet.
- Perform the upscale calibration as detailed above using the audit upscale calibration system.
- Record the results of upscale calibration.
- Disconnect the audit upscale calibration system from the nephelometer calibration gas inlet.
- Connect the audit zero air calibration system to the nephelometer calibration gas inlet.
- Perform the zero calibration as detailed above using the audit zero air system.
- Record the results of audit zero calibration.

- Disconnect the audit zero calibration system from the nephelometer calibration gas inlet.

Option 2: Zero value determined using the nephelometer's internal zero air system pump and tubing with an independent audit filter

Note that this option only isolates the zero air filter. Problems with the nephelometer zero air pump or tubing may not be detected using this approach.

- Replace the nephelometer zero air filter assembly with an audit filter assembly.
- Disconnect the station upscale calibration system from the nephelometer calibration gas inlet.
- Attach the audit upscale calibration system to the nephelometer calibration gas inlet.
- Perform the upscale calibration as detailed above using the audit upscale calibration system.
- Record the results of upscale calibration.
- Perform the zero calibration as detailed above using the audit zero air system.
- Record the results of audit zero calibration.
- Disconnect the audit upscale calibration system from the nephelometer calibration gas inlet.

4.2 NEPHELOMETER INSPECTION

The nephelometer inspection verifies that the instrument is capable of making an ambient reading and that the nephelometer components necessary for correct operation are not contaminated. Most of the nephelometer mechanical functions are tested during the Power-On-Self-Test (POST) described above. The nephelometer calibration can be affected by contamination in the light trap and clean air filter. The nephelometer inspection includes the following procedures:

CHECK THE INLET SCREEN — Check the nephelometer inlet screen for dirt and debris that can impede the flow of air into the sample chamber.

CHECK THE FAN OUTLET — Check the sample fan outlet screen for debris that can impede the flow of sample air through the nephelometer.

CHECK THE LIGHT TRAP — The light trap can collect water and other debris that can affect the nephelometer. Check the light trap for contamination as follows:

- Remove the light trap by unscrewing it from the bottom of the nephelometer.

- Examine the light trap for water or other contamination. Note any contamination.

- If necessary, remove water and other debris and gently clean and dry the inside of the light trap with a lint-free cloth.

- Replace the light trap.

CHECK THE CLEAN AIR FILTER

The clean air filter assembly can collect water during severe weather. The filter cartridge can be contaminated by water trapped in the assembly. Check the clean air filter assembly as follows:

- Remove the clean air filter assembly from the nephelometer by turning the entire assembly counter-clockwise.

- Remove the cover from the assembly by turning the cover counter-clockwise.

- Remove the filter cartridge from the assembly by turning the cartridge counter-clockwise.

- Examine the clean air assembly and filter cartridge for water or other contamination. Note any contamination.

- If necessary, remove water and other debris and gently clean the inside of the clean air assembly with a lint-free cloth. Replace the filter cartridge if it is contaminated.

- Replace the clean air filter cartridge, assembly cover, and entire assembly in the reverse order they were removed.

4.3 POST-INSPECTION AUDIT CALIBRATION

The nephelometer post-inspection audit calibration is performed following inspection of the nephelometer clean air filter or light trap. The post-inspection audit calibration represents the state of the instrument after the audit is complete. The calibration is identical to the pre-inspection audit calibration described in Section 4.1.2, Calibration Using Station Calibration System.

4.4 OPERATIONAL CONFIGURATION VERIFICATION

Following the audit, verify that all nephelometer components are in their operational configuration and that the nephelometer is in ambient mode. Specifically:

- Reconnect the station span gas hose to the nephelometer span gas port.

- Verify that the station span gas tank valve is turned completely off.

- Verify that the span gas hoses are disconnected at the rotameter.
- Verify that the operational clean air filter assembly is in place.

- Verify that the nephelometer is operating in the correct ambient mode.
- Verify that all datalogging systems are in their standard configuration.

4.5 AUDIT RESULTS REPORT

Nephelometer audit results are reported by:

- Comparing the nephelometer's audit zero and upscale calibrations to the station zero and upscale calibrations to verify correct instrument operation
- Comparing the nephelometer's audit zero and span (span = upscale - zero) calibration to the installation zero and span calibration values to quantify how the instrument has changed since installation
- Fully describing any inconsistencies noted during physical inspection of the system

4.5.1 Nephelometer Audit Calibration vs. Station Calibration

The nephelometer audit and station zero and upscale calibration values are compared to verify correct instrument operation. Tables 4-1 and 4-2 show examples of nephelometer audit and station calibration results. The nephelometer audit results indicate the instrument is operating correctly when:

- The percent difference between the audit and station calibration values is less than 15%
- The absolute difference between the audit and station calibration values is less than 5 counts
- Span gas flow rates are greater than 2 lpm (4 lpm optimal). If the span gas flow is less than 2 lpm the audit results are suspect because the nephelometer chamber may not have filled properly with span gas.

4.5.2 Nephelometer Audit Calibration vs. Installation Calibration

The nephelometer audit span calibration (difference between the audit upscale and zero calibrations) is compared to the installation span calibration to quantify how the instrument has changed since installation. The installation calibration values may be obtained from ARS. Table 4-3 shows an example nephelometer audit and installation calibration comparison. The comparison indicates the instrument is operating correctly when the percent difference between the audit and initial span calibrations is less than 15%.

4.5.3 Description of Physical Conditions

The audit report should include a complete description of any inconsistencies noted during physical inspection of the nephelometer that could affect the performance of the system.

Table 4-1

Example Nephelometer Audit Zero Calibration vs.
Station Zero Calibration Comparison

	Station Zero Calibration (Counts)	Audit Zero Calibration (Counts)	Absolute Difference (Counts)	Percent Difference [Audit-Station] / Station
Pre-Inspection Calibration	55	54	1	1.8 %
Post-Inspection Calibration	55	53	2	3.6 %

Table 4-2

Example Nephelometer Audit Upscale Calibration vs.
Station Upscale Calibration Comparison

	Station Reference Upscale Span (Counts)	Audit Reference Upscale Span (Counts)	Absolute Difference (Counts)	Percent Difference [Audit-Station] / Station
Pre-Inspection Calibration	130	131	1	0.7 %
Post-Inspection Calibration	126	127	1	0.8 %

Table 4-3

Example Nephelometer Audit Span Calibration vs.
Installation Span Calibration

	Audit Span Calibration (Upscale-Zero) (Counts)	Installation Span Calibration (Upscale-Zero) (Counts)	Percent Difference [Audit-Installation] / Installation
Initial Calibration	131 - 54 = 77	107 - 34 = 73	5.5%
Final Calibration	127 - 53 = 74	107 - 34 = 73	1.4 %

4.5.4 Distribution of Audit Results

One copy of the audit results should be mailed or FAXed to ARS and a second copy should be mailed to the project sponsors or other contract designated project personnel. If major problems are noted, the auditor should call ARS as soon after the audit as possible so that corrective actions can be initiated. The distribution of additional audit reports will depend on individual network monitoring plans.